SOIL SURVEY OF THE LIVERMORE AREA, CALIFORNIA.

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DESCRIPTION OF THE AREA.

Contra Costa and Alameda are adjoining counties in the western part of California, bordering on the east side of San Francisco Bay. Their combined area is nearly 1,600 square miles. The area surveyed is situated near the eastern border of these two counties, lying mainly in Alameda.

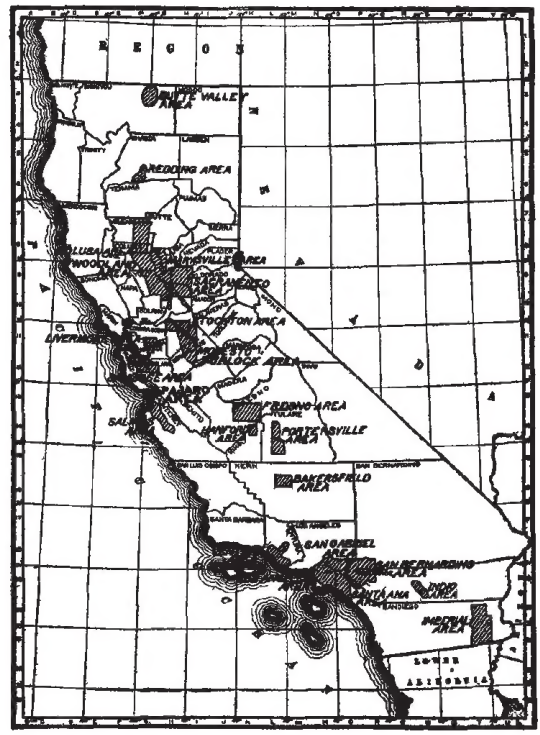


FIG. 51.—Sketch map showing location of the Livermore area, California.

The area is very irregular in outline. The most southerly point is reached in the Sunol Valley, where it extends to parallel 37° 30′ north latitude; the most northerly point falls only one-half mile short of 37° 50′. East and west it extends from meridian 122° west of Greenwich, at Danville, to 121° 37′, near Altamont. The irregularity in outline is due to physiography, the work in most cases being extended to include the less rugged and cultivated areas. The extreme length of the area from north to south is 20 miles and its greatest width 18 miles. The total land area is 155,520 acres, or 243 square miles.

The topographic features consist of mountains of considerable altitude, the level undulating foothills, and the valleys, by far the greater proportion of the area being in the second class. The valley

lands, which are included in the San Ramon, Tassajero, Livermore, Sunol, and Amador Valleys, are comparatively level, although somewhat interrupted by more or less well-defined terraces, swells, and depressions marking old stream courses, and in a few cases by small "hog-wallow" areas. The mean elevation of the valley floors is between 400 and 500 feet above sea level.

The valleys are surrounded by undulating foothills with rather steep slopes and more or less rounded peaks and ridges that have an elevation of 700 to 800 feet, while the mountainous areas which lie back of them are generally steep and rugged, the highest elevation in the area—2,000 feet—being reached in the Black Hills north of Livermore.

The water courses of the area are numerous, but all except a few of them are dry during the summer months. The principal ones are Arroyo Mocho, Arroyo del Valle, Arroyo de la Laguna, Arroyo las Positas, Tassajero, and Alameda Creeks. Of these Arroyo Mocho, Arroyo del Valle, and Alameda Creek are the largest and have their sources in the mountains south of the area. Alameda Creek, with its main branch, San Antonio Creek, drains the southwestern part of the area. The Arroyo las Positas drains the eastern portion of the valley, while the Tassajero drains the valley of that name. Thus, with the exception of a small area to the eastward, which drains into the San Joaquin River, and the northwest corner, the waters from which flow into San Ramon Creek, the drainage of the area finally finds its way into San Francisco Bay through Alameda Creek. Just northeast of Livermore are two small lakes which during the winter cover several acres, but become nearly or quite dry in the summer.

Contra Costa County, originally embracing a large part of what is now Alameda County, was established in 1849. Four years later Alameda County was created from parts of Contra Costa and Santa Clara Counties. Some time later the county was divided into townships, two of which, Murray and Pleasanton, include practically all that part of the survey located in Alameda County. The first settlement in this part of the area was made near Dublin in 1826 by Don José Amador. He was followed in a few years by Robert Livermore, an Englishman, who took up some land near the present town of Livermore. In 1835 Amador was granted 16,516 acres by the Mexican Government and four years later several other large tracts of land were secured in the same way by a number of settlers, mostly Mexicans. These early settlers devoted themselves entirely to stock raising.

From the time Robert Livermore entered the valley a few settlers drifted in, but very slowly up to the year 1848, when gold was dis-

covered. As a result of this discovery many men came into the State, a number of whom settled in the area. It was not, however, until the completion of the Central Pacific (now the Southern Pacific) Railroad, in 1869, that settlement became rapid. That year the present towns of Livermore and Pleasanton were laid out and for a few years grew quite rapidly. In 1883 Livermore had about 1,500 inhabitants and Pleasanton somewhat less than half that number. Since then the towns have grown slowly.

In addition to the descendants of the early Mexicans and Americans, many other nationalities are represented in the valley. Among them are a few Irish who came in about the time the railroad was completed, French and Italians attracted by the wine interests, and Portuguese who came in from other sections of the State. There also are a number of Danes, Slavs, and Germans. In the aggregate these different nationalities represent a large percentage of the population and it is doubtful if a more cosmopolitan people can be found in any other section of the State.

As a rule the farm buildings are substantial, commodious, and neatly painted, and the fields are well fenced. There are, however, some rented farms that are very poorly equipped with buildings and fences.

The main country roads are well graveled and are seldom muddy during the rainy season. During the summer they are sprinkled every day and are thus at all times in excellent condition. In the hilly country, however, while the roads are hard and smooth during the dry season, they become almost impassable during the rainy season, owing to the very sticky nature of the adobe soils.

There are no large towns in the area, although there are a number of small ones that are in a prosperous condition. The largest of these, Livermore, is located in the eastern portion of the area and has a population of about 2,000. Other towns are Sunol, in the southwest corner; Danville, in the northwest corner; and Pleasanton, near the western side of the valley.

For a number of years there was only one line of railroad operating in the valley. Later the Southern Pacific built a line from Martinez to San Ramon. This line was completed to the main valley line and has been open to passenger and freight traffic for little more than a year. In addition the main line of the Western Pacific has just been completed and parallels the Southern Pacific through the valley. With competing roads it would seem that the farmers should secure good service and low rates. Being only about 40 miles from the bay cities, the markets are excellent.

CLIMATE.

Livermore Valley has two seasons—the wet and the dry. The former or winter season begins usually in October, though often November is dry, and terminates about April. The "settled" rains occur during a period of three months. Frequently during this period a cessation occurs for a week, the rains, if any, falling in the night. During the coldest part of the winter the temperature drops a few degrees below the freezing point, and even on days when the morning is coldest, the afternoon becomes warm and pleasant. Snow rarely falls in the valley, and then melts immediately, although it may remain for several days or weeks on the surrounding hills and mountains.

The dry season begins in June and, as stated before, sometimes lasts until December. This period is one of uninterrupted clear weather. The thermometer occasionally registers as high as 110° F., but the hottest spells are usually accompanied by dry north winds and the high temperature is less oppressive than 90° or 95° near the coast. Generally speaking, as the heat of the day increases, a breeze springs up from the west, growing gradually in strength until shortly past noon, when it begins to decline. No matter how hot the days, they are always followed by cool nights.

Unlike the condition in the great interior valleys and in many places along the coast, fogs are locally comparatively rare, the number of foggy days seldom exceeding ten or twelve in a single year. This is largely due to the elevation of the valley and to the fact that it is completely surrounded by hills that shut out most of the fogs.

The average annual rainfall at Livermore is 15.3 inches, but is somewhat greater along the western side of the area. According to observations made at Pleasanton, which is only 6 miles from Livermore, the yearly rainfall is from 2 to 3 inches greater. This difference seems to hold for all of the eastern slope of the Contra Costa Range.

The prevailing wind varies with the season, but taken for the year it is from the west.

The normal monthly and annual precipitation and temperature and the dates of frost occurrence, as shown by the records of the Weather Bureau station at Livermore, are given in the following table.

Normal monthly, seasonal, and annual temperature and precipitation at Livermore.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*
December	50	84	23	3.1	0.7	6.2
January	49	85	20	2.8	2.5	4.0
February	52	89	26	2.3	0.6	5.3
Winter	50	.....	.....	8.2	3.8	15.5
March	54	90	29	2.2	1.1	5.9
April	57	94	30	1.2	0.1	2.7
May	61	104	38	0.6	0.4	0.2
Spring	57	.....	.....	4.0	1.6	8.8
June	68	108	41	0.2	0.0	1.7
July	70	111	41	T.	0.0	0.0
August	70	112	45	T.	0.0	0.1
Summer	69	.....	.....	0.2	0.0	1.8
September	68	106	42	0.3	0.0	0.3
October	63	104	35	0.8	1.3	1.1
November	55	85	28	1.8	1.3	T.
Fall	62	.....	.....	2.9	2.6	1.4
Year	60	112	20	15.3	8.0	27.5

Average date of first killing frost in autumn, Dec. 2; of last in spring, Feb. 23. Date of earliest killing frost in autumn, Nov. 9; of latest in spring, Apr. 12.

AGRICULTURE.

At the opening of the year 1848 there were in the whole valley only a handful of men, who were engaged in stock raising. During that year, however, the discovery of gold brought men from every part of the country into California, a few drifting into the Livermore Valley. They also took up stock raising, and by 1855 it is estimated that there were 50,000 head of cattle in the region. Very few attempts at agriculture had been made, it being generally believed that the soil would produce nothing but grass. Grain and vegetables had been raised, but only in a very small way. Everybody was interested in stock raising and no other industry had been thought of. In 1856, the first field of grain sowed in the valley, 160 acres of wheat, was harvested. The following year wheat raising began in the west end of the valley, where 800 acres were sowed and harvested. In 1864 large yields were secured in the east end of the valley, and as a result the acreage was greatly increased in the succeeding years. The large yields from

these lands started immigration. Settlers came in great numbers and either by purchase or preemption located in all parts of the district.

There were, however, two drawbacks to the immediate development and improvement of the country. The first was the lack of shipping facilities. All grain grown in the eastern end of the valley had to be hauled to Morris Landing on the San Joaquin, while the grain from the western portion of the valley was hauled to Eden and Roberts Landing, on San Francisco Bay. As the country was new and the roads unimproved, these long hauls were a heavy item of expense.

The second and greater drawback was the uncertainty of land titles. The chief cause of this was the doubt regarding the boundaries of some of the Mexican land grants. This matter was definitely settled in 1871 by a decision of the Secretary of the Interior—a decision which threw open for preemption a large section of country. Coming as it did, immediately after the completion of the railroad through the valley, this decision resulted in a large influx of settlers.

As is usually the case with increased settlement, stock raising was almost entirely abandoned, and for a number of years the attention of the farmers was given to wheat production, the average yield for this time being in the neighborhood of 30 bushels per acre, although yields of 40 and 50 bushels, and even more, were reported.

After a time, however, under a system of continuous cropping to wheat, the yields began to decline, and wheat growing became less profitable. Barley was then introduced, and as the yields secured from it were much greater it remained the leading grain crop for a number of years; then owing to decreasing yields it, too, became less profitable, and attention was turned to the production of hay, which has since been the leading agricultural product of the valley.

For either of these crops the plowing and seeding operations begin in the fall as soon as the rains have moistened the soils sufficiently, and may continue until spring. In breaking the valley soils a sulky plow that turns two furrows is used. This is followed with a disk harrow or cultivator and finally, after seeding, with a spike-tooth harrow. In the hilly portions of the area, however, the ground is ordinarily broken with a riding cultivator early in the fall. It is then left until seeding time, when the grain is sowed with a broadcast seeder. The land is then cultivated a second time, and finally smoothed with a spike-tooth harrow. In some cases, however, the seed is sowed before the soil has been stirred, the subsequent shallow cultivation being the only preparation the land receives.

In the early spring the valley and low hill lands are rolled to crush the lumps of earth and thus prepare the land for harvesting operations, which usually begin about the middle of May and continue for several weeks. That part of the crop that is to be turned into hay is harvested first, the work being done by means of the common mower and hay rake.

The reaper and binder is used in cutting the grain, and although the combined harvester has been tried and is still used to a limited extent, it has not given general satisfaction. The thrashing is done in the field, the straw being stacked for future use. Some straw is baled and shipped out of the area.

Over one-half the area seeded to hay and grain is in wheat, while barley stands second in acreage. Wheat and oats are used almost entirely for hay, while barley is ordinarily cut for grain. But whether a certain crop is to be cut for hay or grain is never definitely determined until harvest time, when the condition of the crop and the prospective market price for hay and grain decide the question. If, for instance, the price of grain is high, the wheat field free from weeds, and the chances good for a large yield, it may be left for grain; otherwise it is cut for hay. Barley is seldom cut for hay, as it usually produces fair yields of grain and the hay does not command as high a price as wheat hay, the latter being worth $3 or $4 more a ton. Wheat hay as a rule brings a little more than oat hay. The varieties of wheat commonly sown are White Australian and Bluestem. Although the red is the leading variety of oats, some good results have been recently secured with the black oat.

The yield of hay from year to year averages about 1½ tons per acre. The average yield of barley is 25 bushels and of wheat 20 bushels per acre.

At one time summer fallowing was followed quite extensively, but except on a few of the very light textured soils this practice has been largely abandoned, as it has been found that the subsequent yields hardly justify the extra expense. Where practiced on the stronger adobe soils the succeeding hay crop is so rank and coarse that it does not command the highest market price, and as it seldom fills or matures it is practically valueless as a grain crop. Consequently it is becoming customary to substitute for summer fallowing some system of rotation which includes a year of pasture, the common practice being to pasture every third or fourth year. Many farmers follow a year of pasture with wheat the first year, barley the second, and oats for hay the third. While more attention is being paid to rotation than formerly, there are a number of farmers who still crop the land continuously, although they may plow only once in three or four years, securing in the intervening years what is called a volunteer crop. This crop, which consists largely of wild oats, in some seasons has considerable value, but the hay does not bring the highest market price. San Francisco and Oakland are the leading markets for both hay and grain, although small shipments are made to all parts of the United States. While some of these crops are marketed from the field, the greater part of the hay is stored in warehouses and shipped as occasion demands. From

50,000 to 75,000 tons of hay are sent annually to outside markets. In addition a considerable quantity is consumed in the area.

The yields can undoubtedly be increased and more profitable returns secured by following a rotation in which the land is pastured every second or at most every third year. This system, coupled with deeper plowing and more thorough preparation to collect and conserve the rain should prove very profitable.

About 2,000 acres are annually devoted to the production of sugar beets, one-half of which is worked by a single company and the remainder by small farmers. In preparing for this crop it is customary to break the land in the fall or winter with a sulky plow. Early the following spring the ground is disk harrowed, cultivated, and finally smoothed with a spike-tooth harrow. The seeding, which is done by machinery, begins about the middle of February and may continue until the first of June. As soon as the young plants have attained a sufficient size the land is cultivated. Hoeing and thinning are done by Japanese, Portuguese, and Porto Ricans at a cost of $6.50 to $8 an acre. The number of cultivations varies with the season, but there are usually three or four. Harvesting commences about the middle of August and frequently continues until the middle of December. In this operation the beets are plowed out and the topping done by laborers at a cost of 50 to 75 cents a ton. The total cost of producing a crop of beets is about $30 an acre. The crop is contracted for at $5 a ton delivered on board the cars. The yield ranges from 12 to 16 tons per acre, depending on season. Owing to continuous cropping for a period of 10 or 15 years, the yields have recently decreased. Various fertilizer experiments are being conducted, but these have not progressed sufficiently to permit any definite statement regarding the results.

There are about 600 acres of alfalfa in the area, most of which is in the vicinity of Pleasanton. In a good season five to six cuttings are secured, the total yield frequently running as high as 8 to 10 tons per acre. However, such results can be secured on the majority of soils only with irrigation.

Some small truck gardens are located on the sandier soils in the vicinity of Santa Rita and Pleasanton, and under a system of thorough cultivation fair results are secured during spring and early summer. Without irrigation, however, this industry will not be profitable during the dry season over the greater proportion of the area.

At one time there were 400 acres in hops just north of Pleasanton, but owing to the low prices of recent years the acreage has been decreased to 150. The yields were large, and it is said that the hops produced here were the finest in the State.

The production of wine grapes is and has been for a number of years one of the important industries in the area. Although a few vines had been planted several years prior to 1880, it was not until that year that the industry entered upon its present era of development. During that year two men purchased some land and started a vineyard. They were followed by Julius Paul Smith, who set out 600 acres. Encouraged by the example of these men, many others took up viticulture, and during the period from 1880 to 1884 over 4,000 acres of vineyards were planted. At that time many small growers went into the business, but as the profits did not prove to be as great as they anticipated many of them have dropped out. As a result the acreage has decreased until at present there are not over 2,500 acres of vineyard in the area, the greater part being owned by men or companies who have much capital invested in equipment. Most of these men are still keeping up their vineyards, displacing the old vines with young ones. At present there are in the area 11 or 12 well-equipped wineries, with a capacity of 100,000 to 300,000 gallons each, and half a dozen smaller ones.

The vines are ordinarily started from cuttings and planted during the wet season, the cuttings being set so as to be 7 or 8 feet apart each way. About five years are required to bring them into bearing. A bearing vineyard is valued at $300 an acre. Deducting $100 to $125 an acre for the bare land, this leaves $175 an acre as the cost of bringing a vineyard of phylloxera-resistant vines to maturity. The cost for a nonresistant vineyard would not be so much, the cost of cuttings being considerably less.

Cultivation of the vineyards commences the latter part of February or first of March. The land is plowed twice. The first time the furrow is turned from the vines, leaving a narrow ridge which is afterwards chopped out between the plants with a hoe. At the second plowing the earth is thrown toward the plants. This is soon followed with a crusher or harrow that smooths the surface for the cultivator. The number of subsequent cultivations varies from four to six, depending on the season. Picking begins about September 15 and may continue until frost. During the winter the vines are pruned, being cut back to two eyes to a cane, with six to eight canes to a vine, depending on its size.

The total cost of pruning, plowing, and cultivation is about $10 an acre. Allowing $1.50 a ton for picking, this brings the cost of producing a crop up to $15 or $20 an acre, not including the cost of hauling to the wineries. The average yield for white grapes is 5 to 6 tons, and of the red 3 to 4 tons per acre. Nearly every year the vines bear a second crop, but it is seldom of enough importance to pick oftener than one year out of three. The yield of this second crop is ordinarily from 1 to $1\frac{1}{2}$ tons, although it may sometimes

exceed this. As tne second crop has a much lower sugar content it is not as valuable for wine making. While the yields secured here are considerably less than in many other sections of the State, the quality of the white grape for wine making can not be excelled anywhere.

The leading varieties of the white grape are Burger, Sauvignon vert, Semillon, and Palomino. The reds are Matero, Carignane, and Zinfandel.

Practically every vineyard in the area is more or less infested with phylloxera. Where a vineyard is set out on new land this does not materially shorten the profitable bearing life of the vines, which is about 25 years. If, however, a new vineyard be located adjoining a badly infested field, the vines will be of little value after the tenth or twelfth year. The effects of this disease can be diminished and the profitable bearing period extended by keeping the vines in a healthy growing condition through the use of commercial fertilizers and thorough cultivation. Most of the new vineyards are being planted with some resistant variety.

Until quite recently no fertilizing had been done, but within the past two or three years excellent results have been secured in some vineyards by drilling in commercial fertilizers.

The prices received for grapes are subject to considerable fluctuation. They have sold as high as $25 and as low as $7 or $8 a ton. There is very little profit in growing them when the price falls below $12 or $15. Some of the wines produced here are not excelled in any part of the country in quality and flavor.

At one time there was quite a large acreage in almonds, but most of these trees are being taken out. While the trees make an excellent growth, there is little or no profit, as owing to late frosts and destructive rains and winds a crop is secured only about one year out of five.

Prunes, cherries, pears, apples, peaches, olives, and apricots are grown to a limited extent, and on some of the moist and productive soils, under a system of thorough cultivation, a good tree growth and abundant crop is secured. As a rule, however, owing to insufficient rainfall, the fruit is apt to be rather inferior in size to that grown under more favorable moisture conditions. With the development of any practicable irrigation system and with such a wide range of soils and climatic conditions it would seem that almost any fruit could here find a favorable environment. At present the only orchards of any size are found near the towns of Sunol, Danville, and Pleasanton. Of these sections that around Danville, owing to more favorable moisture conditions, is giving the most satisfactory results.

There are a few garden patches of strawberries which have done fairly well, but all these are watered during the dry season, and any

attempt to grow berries on the majority of soils without irrigation will probably result in failure, and should be discouraged.

At present more attention is being given to the production of fine blooded draft and race horses than any other branch of stock raising. The area is peculiarly adapted to this enterprise, because of its fine pasturage and the quality of its hay, which is unexcelled for racing stock.

There are a few large dairies in the area and nearly every farmer keeps some milch cows, yet the industry is not receiving the care and attention it should. At present the cream is shipped to Alameda or sold at the local creameries, of which there are three in the area, located at Danville, Livermore, and Santa Rita. As dairy products always command a good price and as the large markets are so near at hand, there would seem to be excellent opportunities along this line.

Comparatively few beef cattle and sheep are marketed from the valley.

Poultry and poultry products command good prices at all times and excellent opportunities are offered to those interested in this industry. At present nearly every farmer has a small number of hens and there are, in addition, several well-managed chicken ranches. The White Leghorn seems to be the favorite breed.

Farm hands hired by the year command $30 a month and board, while day laborers receive $1.25 to $2.50 a day, depending on the season and character of the work.

Probably more than half the farms in the area are operated by the owners, the rest being rented for periods of one year or more by share and cash tenants. The share tenant furnishes everything and gives one-third to one-fourth the crop. Cash rents range from $2 to $6 an acre, according to location and character of the land. No definite data regarding the size of farms are obtainable, although it is quite probable that there are more of 160 acres than any other size. While there are a number of smaller tracts there are also many large ranches ranging in size from 1,000 to 30,000 acres, which would bring the average of farm acreage somewhat above 160 acres. The price of land has increased considerably in the last few years. Acreage valuation ranges all the way from $10 to $300, according to locality, state of improvements, and character of the soil.

Owing to the comparatively small unevenly distributed rainfall and the lack of any irrigation system, the best results can only be secured by taking great care to conserve the soil moisture. For all crops the land should be broken much deeper and prepared more thoroughly than at present. In growing cultivated crops the soil should receive a sufficient number of shallow cultivations to preserve a dust mulch and thus retard the evaporation of moisture.

Many of the soils of the Pleasanton, Livermore, and Ulmar series would be benefited by applications of lime, while in case of practically all the soils stable manure or the plowing under of some leguminous crop should increase the yields.

SOILS.

The soils in the Livermore area have resulted from the decomposition of a variety of rocks, the majority of which have been not at all or only slightly metamorphosed. However, in the vicinity of Mount Diablo and again in the southeastern part of the survey are comparatively small areas of metamorphic rock, the last-mentioned area extending in as a tongue from the higher hills to the south. The Contra Costa Hills on the west and the Mount Diablo Range on the north and east are composed chiefly of Tertiary and Cretaceous strata. These rocks consist of sandstones, limestones, conglomerates, and argillaceous shales. From these two groups of rocks—the metamorphic and sedimentary—nearly all the soils in the area have resulted, though subsequently modified by the various processes of weathering, erosion, transportation, and deposition.

Based principally on topography, the soils fall naturally into two more or less well-defined groups—the valley soils and the upland soils. Each of these groups, when considered from the standpoint of origin, color, and agricultural value, have been separated into series, the series being designated by some local name, and, based on texture, these series have been separated into types, such as sandy loam, loam, and clay loams, each type being shown in the accompanying map by a definite color.

The upland soils are separated into two groups, the residual and the sedimentary, the former comprising the types mapped as Contra Costa sandy loam, Diablo clay adobe, and the members of the Altamont and Vallecitos series, and the latter the Pleasanton series.

There are also two local types in this group of soils—the Contra Costa sandy loam and the Diablo clay adobe. Both are residual, the former being derived from the decomposition of sandstones and conglomerates, and embracing only a very small territory. The latter is the most extensive type in the area. It is derived chiefly from the decomposition of the underlying limestones and calcareous sandstones and shales, principally of the Tertiary age.

The Altamont series comprises two types, a clay loam and a clay adobe. These soils are largely residual, having been derived from the decomposition of the underlying calcareous sandstones and shales, principally of the Tertiary age.

The Vallecitos series is of minor importance, embracing three types, the loam, stony clay loam, and clay adobe. These soils are

largely residual and, unlike the soils of the Altamont series, they owe their origin chiefly to the decomposition of metamorphic rocks.

In the upland group of soils the Pleasanton series is one of the most extensive in the area and embraces five types, the Pleasanton sandy loam, gravelly sandy loam, loam, gravelly clay loam, and clay adobe. It is a difficult matter to make any definite statement regarding the origin of this series. Many exposures are found, some of which are 200 to 300 feet in thickness, but in none of these can any rock be found. Instead alternating strata of silts, silty clays, and clays with occasional pockets of gravel occur. Based on these facts, the series would seem to be of sedimentary origin.

The valley soils fall into three groups—purely alluvial, alluvial modified by swamp conditions, and largely colluvial but mixed with alluvial material. The first class in the valley soils is represented by the Mocho series, the second class by the Santa Rita series, and the third class by the Livermore, Dublin, and Ulmar series and a number of local types.

The Mocho series embraces four types—gravelly fine sandy loam, sandy loam, fine sandy loam, and loam. They constitute the most recent soils in the area and are still in the process of formation.

The Santa Rita series comprises three types—a loam, silty clay loam, and clay adobe. These soils also are comparatively recent and in most cases have been deposited under swampy conditions.

The Livermore series includes a fine sandy loam, a silty fine sandy loam, a gravelly sandy loam, a loam, a clay loam, and a clay. These soils are composed largely of material that has been washed from the upland soils of the Pleasanton series.

The Dublin series includes four types—the loam, clay loam, clay loam adobe, and clay adobe. The types are composed of colluvial and alluvial material washed from adjoining hills.

The Ulmar series embraces two types, a fine sandy loam and loam.

In addition there are a number of individual types that could not be grouped with any series because of their marked dissimilarity in texture, origin, agricultural value, and mode of formation. Such types are the Tassajero clay loam, Danville clay loam adobe, and Sunol loam. However, none of these are very extensive, and are largely of colluvial wash modified by alluvial deposits.

In the case of nearly all the soils the topography of the surface is such as to insure good natural drainage. There is, however, one type, the Santa Rita clay adobe, which requires artificial drainage before the best results can be secured.

The names of the several types, together with their actual and relative extent, are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Diablo clay adobe	52,096	33.5	Vallecitos stony clay loam	1,280	0.9
Dublin clay adobe	14,848	9.5	Vallecitos loam	1,280	.9
Pleasanton loam	12,160		Vallecitos clay adobe	1,216	.8
Yellow clay subsoil phase	192	8.4	Dublin clay loam adobe	1,152	.7
Loam subsoil phase	768		Dublin loam	896	.6
Altamont clay adobe	11,136	7.1	Livermore silty fine sandy loam	832	.5
Livermore gravelly sandy loam	9,600	6.2	Pleasanton gravelly clay loam	832	.5
Pleasanton gravelly sandy loam	8,960	5.8	Santa Rita loam	832	.5
Pleasanton clay adobe	5,568	3.6	Ulmar fine sandy loam	832	.5
Ulmar loam	3,584	2.3	Tassajero clay loam	832	.5
Livermore loam	3,520	2.3	Contra Costa sandy loam	704	.4
Santa Rita clay adobe	3,456	2.2	Mocho loam	576	.4
Mocho gravelly fine sandy loam	3,136	2.0	Livermore clay loam	576	.4
Pleasanton sandy loam	3,008	1.9	Mocho fine sandy loam	512	.3
Altamont clay loam	2,816	1.8	Livermore fine sandy loam	448	.3
Livermore clay	2,432	1.6	Sunol loam	448	.3
Mocho sandy loam	2,048	1.3	Danville clay loam adobe	256	.2
Santa Rita silty clay loam	1,344	.9			
Dublin clay loam	1,344	.9	Total	155,520	

CONTRA COSTA SANDY LOAM.

The Contra Costa sandy loam, to a depth of 12 to 30 inches, consists of a sandy loam or loamy sand, which varies in texture from coarse to medium and carries considerable amounts of rounded gravel. When wet it is a brown or brown with a reddish tinge. The dry surface is usually a dull yellow or yellowish gray. On the crests of the ridges and near rock outcrops the soil rests directly upon the bed rock, while on the lower slopes the subsoil consists of a yellowish-gray, light brown, or a light reddish-brown clay loam often mottled with yellow and gray and extending to a depth of 3 to 5 feet. This is underlain by a thin stratum of yellowish sandy loam, containing fragments of the partially decomposed underlying rock.

Practically all of the Contra Costa sandy loam encountered in this area lies northeast of Livermore near the northern boundary of the survey. Here there are a number of bodies from a few acres to one-half square mile in extent. The main part of the type occupies a low broken range of hills that projects out into the valley. A few small and unimportant bodies are found capping the highest peaks and ridges in this section. The topography is hilly and in places the slopes are quite steep. With the very porous nature of

the soil the drainage is excessive and crops suffer for lack of moisture. The Contra Costa sandy loam is derived, through the processes of decomposition, from coarse-grained sandstone and conglomerates.

The native vegetation consists of live oak and field oak. Except in those cases where the slopes are too steep or the soil is shallow, the type is dry farmed to grain and hay. Most of the land is summer fallowed every three years, but even in the most favorable seasons the yields are very light, seldom exceeding one-half to three-fourths ton of hay per acre. Some small groups of thrifty eucalyptus are found on the type. Judging from their appearance it is quite probable that under present conditions greater returns could be obtained from growing these trees than from farming. The land is valued at $15 to $30 an acre.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Contra Costa sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23052	Soil	3.8	19.1	16.3	20.3	8.8	22.7	8.9
23053	Subsoil	2.3	6.8	4.7	7.8	9.1	26.2	43.1

DIABLO CLAY ADOBE.

In its typical development the Diablo clay adobe consists of about 3 feet of a dark-brown, dark-gray, dark slate-colored, or black heavy sticky clay loam or clay, which is, as a rule, darker in color and heavier in texture on the lower slopes. The type is, however, subject to some variations in both texture and color. While the greater part of the type is heavy enough to be classed as a clay, yet those bodies that are underlain by rock at shallow depths often approach a sandy clay, or even a loam, with very little of the adobe structure. Such areas are too small to be indicated in a map of the scale used in the survey. In addition to black and dark brown, which colors characterize by far the greater proportion of the type, various shades of drab, slaty gray, and even a greenish gray are occasionally seen. When viewed in a bright light, the dry cultivated surface presents a grayish-brown appearance, with black areas along the lower slopes and in depressions.

Large fossil oyster shells (*Astiga titau*) and more or less angular cobbles are found strewn over the surface on some of the peaks and ridges. Occasional outcrops of limestones and conglomerates occur throughout the type.

The soil is very sticky when wet, but dries off rapidly, checking and cracking to such an extent as to leave a loose mellow surface. It never puddles nor becomes compact, as a soil of this texture without the adobe structure is apt to do, and for this reason it is easily cultivated even when very dry.

The depth of the soil is to some extent dependent on the depths to the bedrock. Where this comes near the surface, the soil is necessarily shallow, but where the bedrock is not encountered within 5 or 6 feet the soil is underlain at a depth of 2½ to 3½ feet by a compact grayish-brown or yellowish-gray clay loam, which, like the soil, is subject to more or less variation and may be a silty loam, a silty clay loam, or even a sandy clay.

The Diablo clay adobe occurs in all parts of the area in bodies ranging in extent from a fraction of a square mile to several square miles. As a whole it covers about 33.5 per cent of the total area surveyed. The largest body lies north of Livermore and covers an unbroken stretch of country several square miles in extent, including all the territory as far back as the Black Hills, with the exception of the small flats along some of the stream channels. West of the San Ramon Valley is another area which covers several square miles, extending from Dublin to the northern boundary of the area. The third important body of approximately 3 square miles is located 4 or 5 miles southeast of Livermore. In addition to those already mentioned there are a number of smaller areas in the hills, composed largely of soils of the Pleasanton series, and although these differ somewhat from the typical soil, they have been included with this type.

The topography of the Diablo clay adobe varies from rolling to hilly areas, with steep slopes and high peaks which often reach an elevation of 600 to 700 feet above the valley. It is dissected by intermittent stream channels and deep ravines. In many cases the latter owe their origin to landslides, which occur with considerable frequency during the rainy season and present a serious obstacle to cultivation. The topography differs from that of the Pleasanton series in that the peaks and ridges are more rounded and the slopes not quite so precipitous.

The slope is always sufficient to insure good surface drainage. On the other hand the type has a remarkable capacity for holding moisture, and as the mellow condition of the surface favors absorption, crops do not suffer from drought as quickly as on the lighter textured soil, providing the land be properly prepared.

The Diablo clay adobe is largely a residual soil, although upon the slopes it is modified somewhat by admixture of colluvial material. It is derived largely from the weathering of Tertiary limestones and calcareous sandstones, and shales.

There is not enough alkali in this soil to prevent the growing of any crop, although the presence of salt grass on some of the lower slopes and along the draws indicates small amounts of these salts.

With the exception of a few field oaks, which are found in the higher elevations where the rock is quite near the surface, the Diablo clay adobe is treeless, and practically all the type is dry farmed to hay and grain or used for grazing purposes. In growing hay and grain it is a common practice to pasture every third or fourth year. Summer fallow has been tried, but such a system of farming is not very successful, as it results in a very coarse growth of straw with little grain the following year. Hay yields from 1 to 3 tons, depending on the season, and barley 12 to 25 sacks. It is very probable that these yields could be increased by deeper plowing and more thorough preparation of the soil in general.

Grapes can be grown on this soil, but they nearly always mildew and are of poor quality for wine making. Other fruits have been tried, but the trees are short-lived, probably owing to the excess of lime in the soil. Under existing conditions it would seem that the land, so far as crop adaptation is concerned, is being used to the best advantage. Lands of this type are selling for $10 to $60 an acre, depending on improvements and distance from the markets.

The following table gives the average results of mechanical analyses of typical samples of soil and subsoil of this type:

Mechanical analyses of Diablo clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
22144, 23058, 23060, 23065.	Soil.....	0.3	1.2	1.6	8.4	19.1	38.5	31.0
22145, 23059, 23061, 23066.	Subsoil.....	.3	.9	1.2	7.4	29.8	38.8	21.7

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No 22144, 1.31 per cent; No. 22145, 5.70 per cent; No. 23058, 3.68 per cent; No. 23059, 5.52 per cent; No. 23061 3.24 per cent; No. 23066, 3.60 per cent.

ALTAMONT CLAY LOAM.

The soil of the Altamont clay loam consists of 18 to 30 inches of light-brown to dark-brown heavy silty clay loam or clay loam, carrying a considerable quantity of shale and other angular rock fragments. The dry cultivated surface has a yellow or sometimes reddish-yellow color, and quite frequently becomes very much like adobe. It is underlain to a depth of 6 feet, or until rock is encountered, by a yellow clay loam or silty clay loam that also carries shale fragments, usually in larger quantities than the soil. On the lower slopes where the type grades into the soils of the Pleasanton series, the subsoil

becomes quite red and sticky. Small areas of outcropping sandstone and shale occur upon some of the peaks and ridges and here the soil is usually much shallower, while the proportion of shale and rock fragments is much greater. Where the type is not too steep and stony it is easily cultivated.

Only two bodies of Altamont clay loam have been mapped in the area. The largest of these occurs as a long narrow strip along the east slope of Pleasanton Ridge, extending from Dublin nearly to Sunol. The other body, embracing approximately 1 square mile, lies southeast of the last mentioned town.

All of the type is quite hilly and considerably dissected by gullies and ravines. At times the slopes become so steep as to practically prohibit cultivation. The highest elevation is reached just north of Sunol, where the type attains an altitude of 500 feet above the valley. Although the slopes are steep, the texture of the soil is such, that under proper management it can be made to retain comparatively large supplies of moisture, and were it not for the fact that the crops are subject to such long-continued dry periods they would suffer very little from excessive drainage.

The Altamont clay loam is largely residual, resulting from the decomposition of the underlying rocks in place. The slopes, however, have been more or less modified by the addition of colluvial material.

The native vegetation consists of a dense growth of live oak, poison oak, maple, and a great variety of small shrubs and trees. At present all that part of the type near Sunol is under cultivation. The body along Pleasanton Ridge is used almost entirely for grazing. The cultivated areas have been dry farmed to hay and grain continuously for a long period of years and as a result the yields have decreased. Ordinarily the yield of hay ranges from 1 to 2 tons. This land could be improved and the yields increased if it were pastured every second or third year. More thorough preparation and the application of stable manure and lime would probably prove beneficial. Land of this type ranges in value from $25 to $150 an acre.

The following table gives the average results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Altamont clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23033, 23054.....	Soil.....	0.6	2.0	1.6	6.3	21.6	42.8	25.6
23034, 23055.....	Subsoil.....	.9	3.7	3.0	6.8	19.9	43.2	22.5

ALTAMONT CLAY ADOBE.

The Altamont clay adobe consists of a brown to dark chocolate brown or reddish brown silty clay loam or clay loam. A few cobbles and shale fragments are found on some of the higher peaks and ridges, but the former are not as common as in the black adobe. Outcrops of sandstone occur with considerable frequency on the steep slopes. Immediately following rains, the soil is exceedingly sticky, but it dries quickly, and, as it dries, cracks and checks in such a manner as to produce a loose and friable surface. Unlike clay loams that lack the adobe structure, this soil never becomes compact and is easily cultivated at all times.

The depth of the soil depends somewhat on the position of the underlying rock, which is found at varying depths below the surface. Where, as in the majority of cases, it is 5 feet or more below the surface, the soil at an average depth of 3 to 4 feet is underlain by a yellowish-brown clay loam, which carries more silt than the soil. Beneath this and overlying the bedrock there is a thin stratum of sandy loam, which has resulted from the partial decomposition of the sandstone or shale rock.

A phase of this type is found in the Black Hills region, where the soil is a brighter red and the subsoil more yellow. The agricultural value and the outcropping rock are not identical with the other areas of this type, but these differences do not seem to warrant establishing a new type.

Only two bodies of Altamont clay adobe have been mapped in this area, but both of these are quite extensive. The most important of these occurs as a large unbroken body, embracing 10 to 12 square miles in the northeastern part of the area. The second body occurs in the Black Hills region on the northern border of the area. This connects with the first-mentioned body outside the survey.

The type is characterized by high hills with rounded tops and steep slopes that become quite precipitous along some of the deep stream courses and ravines. The average elevation of the type above the valley is 400 to 500 feet. At some points in the Black Hills region it attains an elevation of 2,000 feet above sea level. The steep surface and certain properties of the soil have resulted in a large number of landslides, although they are not as numerous or extensive as in the Diablo clay adobe. While the surface features insure ample drainage, the absorptive capacity of the soil checks excessive drainage and permits the retention of sufficient moisture to keep the crop from suffering from drought so quickly as on many of the other lighter-textured soils.

The type is largely a residual soil, derived chiefly from the decomposition of Tertiary sandstones and shales. Only a few limited

areas have resulted from the weathering of limestone or conglomerates. Evidences of alkali are present along the stream courses, but the areas do not attain sufficient size to show on the map.

With the exception of a few scattered field oaks the type is treeless. Formerly this type was dry farmed continuously to grain and hay. As the yields began to decline, some of the farmers introduced a system of summer fallowing. Better results were secured and the practice was followed for a number of years. After a time the yields again began to decline and in recent years it has become customary to pasture the land every third or fourth year. At present from 1 to 2 tons per acre is considered a fair yield of hay. Although the yields are somewhat lighter than on the Diablo clay adobe, it is claimed that the quality is superior, the product bringing the highest market price.

Under existing conditions it would seem that the type is being utilized to the best advantage. However, it is quite likely that the yields could be increased by deeper plowing, more thorough cultivation, and the employment of every other precaution to conserve the soil moisture.

Land of this type brings from $25 to $75 an acre, depending on the distance from markets, the state of cultivation, and the character of the improvements.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Altamont clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23035, 23056.....	Soil.....	0.1	0.9	1.4	4.9	10.4	48.1	34.1
23036, 23057.....	Subsoil.....	.4	1.9	2.5	8.5	13.2	51.8	21.8

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 23057, 8.86 per cent.

VALLECITOS LOAM.

The Vallecitos loam consists of a light-brown or reddish-brown sticky loam or very fine sandy loam 15 to 29 inches deep, underlain by a yellowish to light-brown loam or sandy clay loam. Beneath this at an average depth of 5 to 6 feet, and immediately overlying the bed rock, there is a thin stratum of light-textured, yellow fine sandy loam. Outcrops of metamorphic rocks are common on the higher ridges and in a few cases along the steep slopes.

The type includes two phases. One of these occurs on the steeper slopes where the soil and subsoil are somewhat heavier, often approaching a silty loam or clay loam. A second phase is found on the ridges where the soil is rather lighter in texture than is usual

for the type. In such locations the soil consists of a reddish-brown or light-brown medium to fine sandy loam. As a rule this is underlain by 6 to 8 inches of a light-yellowish gray fine sandy loam, which rests upon bed rock at an average depth of 1 to 4 feet.

Only one typical body of Vallecitos loam occurs in the area. This is located in the hills about 4 miles south of Livermore and covers approximately 1 square mile. Three other small bodies of the sandier phase are found in this same locality.

The type is characterized by a rough, broken topography, with many ridges, steep slopes, and numerous deep ravines. As a result the drainage is somewhat excessive.

The Vallecitos loam is a residual soil formed by the decomposition of metamorphic rocks.

The timber growth is confined principally to the slopes, where live oak, field oak, and buckeye flourish in large numbers. The more level areas are devoted to the production of hay and grain, but the yields are only moderate. The rougher areas are used for grazing. The land is valued at $15 to $35 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Vallecitos loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
22297, 23178...	Soil	0.2	2.3	5.9	20.8	28.7	22.7	19.2
22298, 23179...	Subsoil	.1	1.8	5.2	18.2	30.6	22.2	21.9
23180	Lower subsoil	.0	1.4	4.7	22.4	22.4	32.1	17.2

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 23180, 2.54 per cent.

VALLECITOS STONY CLAY LOAM.

The Vallecitos stony clay loam consists of 10 to 24 inches of brown or reddish-brown clay loam, underlain by light-brown clay loam, which continues until the underlying rock is encountered at an average depth of 36 to 48 inches. When dry, the soil is a grayish yellow or light brown. Where the soil covering is shallow, the clay loam subsoil is often wanting, and there is a layer of yellowish sandy loam immediately above the rock. Small angular rock fragments are found in both soil and subsoil in large quantities. Over a large part of the type there is only a shallow covering of soil over the rock. Outcrops are numerous, enpecially on the steep slopes. Large and small fragments of these rocks are strewn over the surface, but they are much less numerous on the ridges than on the slopes.

One body of the Vallecitos stony clay loam is mapped. This is found in the extreme southeast corner of the area and covers approximately 2 square miles. The entire type is very hilly, with narrow ridges and steep slopes, so that the surface water runs off rapidly. This feature, together with the shallow soil, would almost certainly cause cultivated crops to suffer for lack of moisture.

The Vallecitos stony clay loam is a residual soil. It is derived from metamorphic rocks, through the usual processes of weathering.

The native vegetation consists of field oak, live oak, and buckeye, with several varieties of small shrubs on some of the steeper slopes. In most cases much of the natural growth still remains, as very little of the type has been cultivated. For many years past it has been used for grazing purposes. Under existing conditions the profits derived from this source are greater than could be obtained in any other way. The land is valued at $10 to $15 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Vallecitos stony clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23173	Soil	1.6	5.6	4.5	8.5	17.6	39.4	22.5
23174	Subsoil	1.6	6.1	4.5	8.1	13.4	34.7	31.6

VALLECITOS CLAY ADOBE.

The soil of the Vallecitos clay adobe is a brown or dark-reddish brown clay loam varying in depth from 30 to 36 inches. It rests upon a subsoil of a yellowish-brown or light-brown heavy clay loam or clay, which usually gives place to a light-yellow sandy clay loam at about 4 or 5 feet. The underlying rock is frequently, though not always, encountered within the 6 feet, while small outcrops are occasionally found on the steeper slopes and ridges.

One body of this type embracing approximately 1½ square miles is found about 5 miles south of Livermore. It occupies an elevated position and is marked by rather narrow ridges and deep ravines with steep slopes. The soil is largely residual, having resulted from the decomposition of the underlying metamorphic rocks.

All of the Vallecitos clay adobe is used for grazing purposes or else dry farmed to hay and grain, chiefly the former, the yields being 1 to 2 tons per acre. Owing to the steep topography and insufficient moisture supply this is probably the most profitable system of farming. The yields could be increased by deeper plowing and more careful preparation for seeding. Land of this type is valued at $15 to $25 an acre.

The results of mechanical analyses of the soil, subsoil, and lower subsoil are given in the following table:

Mechanical analyses of Vallecitos clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23181.....	Soil.....	0.0	0.5	0.5	3.7	21.9	37.8	35.6
23182.....	Subsoil.....	.3	.9	.9	6.1	20.1	29.2	42.6
23183.....	Lower subsoil...	.8	4.4	2.8	18.8	13.6	42.4	17.4

PLEASANTON SANDY LOAM.

The soil of the Pleasanton sandy loam consists of a fine to medium sandy loam, 18 to 36 inches deep, carrying varying amounts of fine and coarse angular gravel. When wet the soil is decidedly reddish, but the dry surface is either a light brown or a light brown with a reddish tinge. Considerable gravel is usually found on the surface, this being especially noticeable after rains have exposed the gravel by washing away the fine material. Some rounded and angular cobbles are also scattered over the surface, especially on the higher ridges. The soil is underlain by a red or yellowish-red sticky clay loam which has the adobe structure and is comparatively free from gravel. This stratum of clay is sometimes very thin, or occasionally wanting, but usually varies in thickness from 8 to 14 inches. It is underlain at a depth of 24 to 48 inches below the surface by a yellowish-red gravelly loam or gravelly clay loam, which usually extends throughout the limits of the soil profile. Beneath the gravelly stratum, at depths varying from 5 to many feet, a yellowish-red clay is encountered, while pockets of this same material frequently occur in the gravelly lower subsoil. Those areas which occur just east of Pleasanton carry somewhat larger amounts of gravel than the remainder of the type, but as such areas are very similar in other respects, they have been included with this soil and these bodies designated on the map by the gravel symbol.

The soil is quite sticky and apt to be boggy when wet, puddles easily, and unless cultivated soon after a rain a crust forms on the surface, making cultivation difficult. When once the crust is broken the type is easily tilled.

Several bodies of Pleasanton sandy loam have been mapped in the area, all of which lie at the base of the north slope of the hills that bound the Livermore Valley on the south. All of these bodies are quite small, except the one lying south and east of Pleasanton, which covers approximately an area of 3 square miles. The type occupies nearly level to rolling areas, which may become hilly, often

reaching an elevation of 100 to 150 feet above the valley floor. The slope is usually sufficient to insure good drainage, but the heavy red clay subsoil retards percolation, and the soil often becomes soaked during long-continued rains. However, after the rains cease the type drains so quickly that artificial drainage is in most cases not needed.

The Pleasanton sandy loam is probably sedimentary soil, which has been more or less modified by subsequent weathering, erosion, and reworking. No alkali is found in this type.

The type is practically treeless, although common valley oaks are found at rare intervals. It is either dry farmed to grapes, hay, and grain, or used for grazing purposes. At present grapes are the most profitable crop. When hay and grain are grown, it is a common practice to pasture the land every third year. Under such a system of farming the yields are increased, but even with the most favorable conditions hay seldom yields more than 1 ton per acre. The type affords good pasturage as long as there is an abundance of water, but the best results can not be secured on this soil without irrigation. If a supply of water could be obtained at a reasonable cost, the type should prove well adapted to the production of tree fruits and general farm crops. Practically all of the land is under cultivation. It ranges in value from $50 to $300 an acre, depending on improvements and location.

The following table gives the results of mechanical analyses of typical samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Pleasanton sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Pec cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23140	Soil	3.4	9.1	6.9	18.1	20.8	30.6	11.2
23141	Subsoil	3.5	4.9	5.4	15.5	17.8	24.4	28.5
23142	Lower subsoil	3.6	8.0	6.8	18.6	23.5	17.3	22.2

PLEASANTON GRAVELLY SANDY LOAM.

The soil of Pleasanton gravelly sandy loam consists of a brown or reddish-brown loam, generally carrying perceptible amounts of medium to coarse sand and large amounts of rounded, flattened, and angular gravel, derived from a number of rocks. At times the amount of gravel on the ridges becomes so large that it is impossible to bore more than 1 or 2 feet with the soil auger. Here also the soil is frequently much lighter in texture than on the slopes, where small patches of adobe nearly free from gravel are not uncommon. Many rounded to angular cobbles are strewn over the surface, especially on

the peaks and ridges. As before stated, brown is the predominating color, although some of the lower slopes are quite red. The surface is soft and spongy when wet, but as it dries a crust forms, and unless this is soon broken the soil becomes hard and compact and very difficult to cultivate.

The surface soil is underlain at a depth of 18 to 30 inches by a stratum of grayish-yellow or slightly reddish clay loam, which ranges in thickness from 6 inches to 2 feet. In a few cases it is entirely absent. Beneath this a brown very gravelly clay loam with a very high content of coarse gravel and many angular and flattened cobbles is encountered. In many cases where exposures occur in deep cuts made by streams this gravelly mass is seen to be loosely cemented. It extends to a depth of many feet and is underlain by a bluish silty clay. In a few cases the soil has been eroded from the high peaks and ridges, leaving the compact gravelly subsoil exposed and barren.

With the exception of the three comparatively small bodies along the lower slope of the Pleasanton Ridge, all the Pleasanton gravelly sandy loam mapped is located in that group of hills which occupies the southern half of the area. Here, in addition to a few small bodies, there are three large bodies covering areas of 1 to 3 square miles each.

The topography of this soil as a whole is very rough and broken. Like the gravelly clay loam of the same series, it is deeply dissected by numerous ravines and intermittent stream channels. The slopes are precipitous and the ridges, which are often very narrow, frequently reach an elevation of 500 to 700 feet above the surrounding valleys. Because of this and the open gravelly nature of the subsoil the type is excessively drained, and crops grown on it are almost certain to suffer from an insufficient water supply during the summer months.

The Pleasanton gravelly sandy loam is probably sedimentary in origin, but has been modified, especially on the lower slopes, by subsequent reworking and erosion, although not to so great an extent as the loam and sandy loam of the series.

The native vegetation, which is generally scanty, is confined principally to the ravines. It consists of field oak, live oak, and buckeye. On account of the steep and broken character of the surface, no attempt has been made to cultivate the greater proportion of the type. At present it is used almost entirely for grazing, and this is undoubtedly, under present conditions, the best use to which most of it can be put.

During the late winter and spring months the pasturage is excellent and abundant, but later in the season the grasses become dry and brown. Grapes have been grown quite successfully on some of the

lower slopes. In a few cases grain and hay have been grown, but the yields are nearly always light.

Where attempts to cultivate this soil are made, the best dry-farming methods should be followed in order to conserve the largest possible supply of moisture. The yields could also be increased by the incorporation of large amounts of stable manure or by plowing under some green crop. Applications of lime would also very likely show beneficial effects. The type is valued at $20 to $50 an acre.

The following table gives the average results of mechanical analyses of typical samples of soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Pleasanton gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23124, 23127...	Soil.....	8.5	11.5	7.2	12.9	13.8	32.1	14.1
23125, 23128...	Subsoil.....	5.8	8.9	5.7	12.1	16.0	20.4	30.6
23126.....	Lower subsoil...	16.6	20.2	5.8	5.2	1.6	13.4	37.0

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 23126, 0.77 per cent.

PLEASANTON LOAM.

The Pleasanton loam consists of 12 to 30 inches of brown to deep-red loam, carrying relatively large proportions of fine and very fine sand and varying quantities of medium to coarse gravel, in which quartz seems to predominate. The color varies somewhat with the elevation and locality. That part of the type which occurs on the lower elevations just south of Livermore is a bright red at all times, while near Sunol it is generally a brownish red when wet and takes on a yellowish cast as it dries, the surface finally becoming a yellowish red.

On the ridges the gravel content is frequently considerable, and small areas of a gravelly loam having the surface strewn with angular and rounded cobbles are not uncommon. When wet, the type is apt to be sticky and boggy, but as it dries a crust forms on the surface and unless it is broken in a short time the soil becomes hard and compact. When once the crust is broken, however, the soil yields readily to tillage and the cultivated land has a soft, loamy surface.

The soil is underlain at 12 to 30 inches by a red, yellowish-red, or yellow sticky clay or heavy clay loam, having the adobe structure and carrying only very small amounts of gravel. In a few cases the subsoil is more or less mottled with red and yellow, and it is a noticeable fact that where the soil is red the subsoil is also red, while in those cases where the dry surface has a yellowish-red cast, as is the case near Sunol, the subsoil is a yellowish red or even a yellow.

Beneath the stratum of clay there is nearly always a compact reddish-yellow gravelly loam or clay loam, in which there is a large amount of flattened and more or less angular gravel derived from a variety of rocks. In this stratum, which usually extends to a depth of 6 feet or more, being finally underlain by a yellowish-red clay loam without the gravel, pockets of gravel-free clay are frequently encountered. In a few cases on the peaks and ridges the surface loam is very shallow or almost absent, with the underlying clay very near the surface. The variation from the typical soil is found in areas of small extent, and the differences in agricultural value are hardly great enough to justify establishing a new type. Areas of the type also include a few small tracts of black adobe.

Two phases of this type have been recognized and mapped south of Livermore. The first and most important of these—the loam subsoil phase—differs from the typical soil in that the red clay subsoil is absent and the soil rests on the gravelly loam at a depth of 3 feet. The surface of this phase is level and contains only small quantities of gravel. The second phase—the yellow clay—which occupies low-lying and poorly drained areas, consists of a dark-brown or black soil, underlain at about 18 inches to 2 feet by a yellow clay sometimes mottled with red. Beneath this, at about 3 feet, the gravelly loam is encountered. This phase is generally less productive than the rest of the type. Both of these phases have been indicated on the map by symbols.

The Pleasanton loam is confined almost exclusively to the southern half of the survey, where it is found in a number of bodies ranging all the way from a few acres up to 2 or 3 square miles in extent. It occurs chiefly along the lower slopes of that range of hills which lies between Livermore and Sunol. The two largest bodies are very nearly on opposite slopes, one on the north side and the other on the south side of this range.

In topography the type varies from rolling to hilly, the highest peaks often attaining an elevation of 400 to 500 feet above the surrounding plain. In a few cases the type becomes quite rough, being deeply dissected with ravines and intermittent stream channels.

Owing to the pronounced slope the type is naturally well drained, except for short periods during and immediately following long-continued rains, when the soil becomes thoroughly saturated, as the heavy clay subsoil prohibits rapid percolation. However, the heavy subsoil has a marked moisture-holding capacity, and by thorough preparation and frequent cultivation enough water can be conserved to carry crops through long dry periods.

The Pleasanton loam is probably a sedimentary soil, modified since its deposition by various agencies, such as weathering and erosion. With the exception of a few scattered oaks the type is practically treeless.

So far as agricultural value and extent is concerned the Pleasanton loam is the most important soil of the series. At present practically all of it is under cultivation. A large area near Livermore is planted to wine grapes. The soil seems well adapted to this crop, as the yields are fair and the quality unexcelled. Like nearly all the other soils of the area, by far the larger proportion is devoted to the production of hay and grain or used for grazing. The yields of hay and grain are only moderate. Hay runs from one-half ton to 1½ tons per acre and barley from 6 to 12 sacks, depending on the season and preparation of the land.

Under irrigation the type should prove an excellent fruit, alfalfa, and truck soil. The cost of leveling and the difficulty in securing an adequate water supply are serious problems. The yields at present secured could be increased by deeper plowing, more thorough cultivation, by plowing under some leguminous crop such as cowpeas, and by applications of stable manure. Lime would also undoubtedly prove beneficial.

Land of this type sells for $50 to $300 an acre, depending on location, improvements, and state of cultivation.

The following table gives the average results of mechanical analyses of soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Pleasanton loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
22142, 23135, 23138.....	Soil.....	2.9	3.9	3.7	10.2	19.2	44.1	15.8
22143, 23136, 23139.....	Subsoil.....	2.4	3.7	3.1	8.5	20.7	26.6	34.9
23137.....	Lower subsoil...	5.4	12.2	8.1	13.9	20.8	25.7	14.1

PLEASANTON GRAVELLY CLAY LOAM.

The Pleasanton gravelly clay loam consists of 15 to 30 inches of dark-brown clay loam, carrying considerable quantities of more or less angular fine and coarse gravel. On the ridges this soil is somewhat lighter in texture and of a more gravelly nature than on the steep slopes, where small bodies of adobe, comparatively free from gravel, are occasionally encountered. Many rounded and angular cobbles, derived from a variety of rocks, among which quartzite seems to predominate, are found distributed through the soil, while on the higher elevations these are frequently strewn over the surface in large numbers. In cultivated fields the dry surface has a slightly reddish cast.

The soil is underlain by a yellowish-red or reddish-brown clay loam, which becomes more gravelly and somewhat lighter in texture

4 or 5 feet below the surface. Beneath this gravelly layer, which usually extends to a depth of 6 feet or more, there is a reddish-yellow, adobe-like clay loam several feet in thickness. As a rule this subsoil carries more gravel and fewer cobbles than the soil.

The structure of the type is such as to offer no serious obstacle to the plow or cultivator and were it not for the steep topography the soil could be easily tilled.

One body of Pleasanton gravelly clay loam is shown in the map. This covers an area of approximately 2½ square miles on the south slope of the group of hills lying southeast of Pleasanton, and is closely associated with the other soils of this series. Like all other soils in this particular section the type is characterized by a rough and broken topography, with many ridges and deep ravines, the bottoms of which are frequently 300 to 400 feet lower than the surrounding ridges, thus making conditions favorable for landslides, which often occur during the rainy season.

Because of the steep slopes, the drainage is always thorough and usually excessive, so the crops grown are almost certain to suffer from drought during extended dry periods.

The Pleasanton gravelly clay loam is nearly treeless and devoted almost entirely to grazing. This is probably the best use that can be made of it for the present, as owing to the rough topography irrigation and cultivation must necessarily meet with great difficulties. Like other soil of this series it is probably sedimentary in origin, though it has not undergone as great changes through subsequent weathering and erosion as many of the soils on the lower slopes. The land is valued at $20 to $30 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Pleasanton gravelly clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23122	Soil	6.6	10.7	6.9	14.4	9.4	26.1	25.6
23123	Subsoil	5.6	8.0	6.1	11.5	8.5	30.3	30.0

PLEASANTON CLAY ADOBE.

The Pleasanton clay adobe to a depth of 1½ to 3 feet consists of a dark-brown, sometimes with a reddish tinge on dry surface, sticky clay loam. It frequently carries some angular gravel. Small areas on the ridges have a large amount of gravel in the soil, with many cobbles spread over the surface. On the other hand, small bodies of adobe, free from gravel, are quite common on the slopes and in depres-

sions on the ridges. A large part of the type shows the adobe structure to a great extent.

It is usually underlain by a reddish-yellow sticky clay or clay loam, which soon gives place to a yellowish clay loam or else continues with only slight change in texture until a gravelly layer is encountered at between 5 and 6 feet. In some cases, however, the clay subsoil is absent, and we find the soil resting on a gray or yellowish-gray silt loam or silty loam, which is not underlain by gravel. In deep exposures, resulting from slides, which are common in this type, strata of a gray or yellowish silt loam alternate with strata of a reddish-yellow clay loam or silty clay. Pockets of gravelly loam are frequently present. This structure in all cases extends to a depth of many feet.

The Pleasanton clay adobe is confined to the group of hills which extends eastward from Sunol and between the La Costa and Livermore Valleys. There are four bodies of the type, the largest of which is approximately 3 square miles in extent. The other areas cover approximately 1 square mile each.

The surface is rough and broken, with high, narrow ridges, steep slopes, and deep ravines. The average elevation is from 500 to 600 feet above the surrounding valleys. The steep slopes cause the surface water to run off rapidly, and while crops usually suffer from lack of moisture during the protracted dry spells, yet owing to the heavier nature of the type they do not show the effects of drought as quickly as crops grown on some of the lighter soils of the series.

The Pleasanton clay adobe is probably a sedimentary soil. The native vegetation consists of a scattering growth of live oak, field oak, and buckeye.

A large part of this type is so steep that it can be cultivated only with the greatest difficulty. Such areas are and should continue to be used for grazing. Some small areas are put in hay each year, but the yields are light, seldom exceeding 1 or 2 tons per acre. The land is valued at $20 to $30 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Pleasanton clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23129	Soil	1.5	4.5	3.6	10.4	18.6	28.3	33.2
23130	Subsoil	1.6	3.3	3.1	8.7	21.0	28.6	33.9
23131	Lower subsoil	1.0	2.4	3.0	9.7	24.9	32.7	26.8

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 23131, 1 per cent.

MOCHO GRAVELLY FINE SANDY LOAM.

The Mocho gravelly fine sandy loam consists of 10 inches to 3 feet of a brown, dark-gray or dark grayish-yellow fine sandy loam or loamy fine sand, carrying varying amounts of rounded waterworn gravel. Some small areas are almost free from gravel, while other bodies contain very large amounts. In texture the soil varies from fine to coarse, with by far the greater proportion of fine texture. It is underlain by a bed of coarse gravel many feet in thickness. This subsoil has a very high percentage of rounded cobbles and only very small amounts of fine material.

As the type is loose and porous it is easily tilled, except in those cases where the gravelly subsoil approaches too near the surface.

The type is confined chiefly to the central part of the survey, the largest bodies occurring along Arroyo Mocho, Arroyo del Valle, and Alameda Creek. Other small bodies are mapped in the vicinity of several of the intermittent stream channels, and at the point where they emerge from the hills and spread over the valley floor. The type, as a whole, is comparatively level, although frequently interrupted by numerous abandoned stream channels.

The Mocho gravelly fine sandy loam is one of the most recent soils in the area, and, with the exception of some small bodies of colluvial material along the base of the hills, is entirely alluvial, being formed of materials derived largely from the more or less gravelly soils of the Pleasanton series. Many large sycamore trees are distributed over the type. Owing to the porous sandy nature of the soil and the coarse stony subsoil the drainage of the type is excessive. The better portions of the Mocho gravelly fine sandy loam are dry farmed to hay and grain, but the yields, as a rule, are only moderate. Other areas, which have a shallow soil and which are subject to frequent overflow and washing, are used largely for grazing. With an abundant water supply this should be a very good truck and small fruit soil. The type would be greatly benefited by heavy applications of barnyard manure and by plowing under some leguminous crop. Land of this type of soil is valued at $20 to $200 an acre.

The following table gives the average results of mechanical analyses of samples of the soil and one of the subsoil:

Mechanical analyses of Mocho gravelly fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23109, 23111	Soil	2.7	7.1	6.3	24.9	28.7	23.2	7.2
23110	Subsoil	22.2	31.6	15.5	13.1	5.3	9.3	3.1

MOCHO SANDY LOAM.

The Mocho sandy loam is one of the most variable types in the area. As a rule it consists of a brown to grayish-brown light-textured sandy loam. Frequently it consists of alternating strata of silty fine sand, fine sand, or even coarse sand. Many bodies carry more or less gravel in soil and subsoil.

In depth the soil is also subject to considerable variation. Sometimes it continues with only slight changes to a depth of 6 feet; not infrequently, however, it is underlain at a depth of 3 to 5 feet by a dark-brown to black clay loam or clay. The subsoil is also subject to some variation, as it partakes of the nature of the surrounding soil. Thus, in the vicinity of Santa Rita it consists of the black clay of the Dublin and Santa Rita series, while those areas near Livermore have for their subsoils the soils of the Livermore series.

The Mocho sandy loam is one of the most widely distributed soils of the area. Besides the smaller and less important bodies in the Alameda, Amador, and San Ramon Valleys, there are a number of areas in the Livermore Valley. They usually occur as long narrow strips along the creeks or intermittent stream channels, ranging in extent from a few acres to one-half square mile or more. The land usually has a gentle slope from the creeks toward the adjoining soil type, but the surface is frequently broken by ridges and by the abandoned stream channels.

The loose porous nature of the soil insures ease of cultivation and rather excessive drainage, except in cases where the type is underlain by heavy clay. Where this is the case the downward movement of the water is retarded, and water frequently stands on the surface during the wet season. Even such areas dry rapidly when the rains cease.

The soil, which is one of the most recent in the area and is still in the process of formation, is alluvial in origin. It was deposited when the swift, sediment-laden streams overflowed their banks at flood stage. In other cases the long, narrow areas occur along depressions that mark the courses of the intermittent streams during high water. Such areas are found along Arroyo Mocho, west of Livermore, and Arroyo Seco, east of the same town. The broad area near Santa Rita is due to artificial rather than natural causes, being laid down by floods of the Tassajero Creek, which has been dammed at times and its waters turned over the adjacent fields. This body, as well as some others in the same section, carry some alkali, but the quantity seldom exceeds 0.20 of 1 per cent.

Two of the older bodies support a growth of sycamore, live oak, and willow. The remaining areas, all of which are comparatively recent, are at present under cultivation and destitute of native vegetation.

Some few fruit trees are found on this type in the San Ramon Valley, while the area near Santa Rita is used for truck crops. Fruit growing is not successful, but very good results are secured on the better areas from growing peas, potatoes, cabbages, and other truck. The greater part of the type is dry farmed to grain and hay, but owing to an insufficient moisture supply the yields are comparatively light. All of this type is greatly benefited by applications of stable manure or by plowing under some green crops.

Practically no bodies composed entirely of this type are on the market, and the value placed on it is determined by the value of adjoining lands.

MOCHO FINE SANDY LOAM.

The surface soil of the Mocho fine sandy loam consists of 18 to 24 inches of a brown to grayish-brown, light-textured fine sandy loam. Small amounts of gravel are found on the surface and in the soil where it has been subject to recent stream action. It is underlain to a depth of 6 feet by alternating strata of fine sandy loam, silty fine sandy loam, and fine sand. In the lower depths the subsoil often becomes quite silty, and pockets of grayish sand occur at varying distances below the surface. The color varies somewhat with the texture, but in general it is a light grayish brown, sometimes faintly mottled with gray or yellow. The position and texture of the various strata are subject to such wide variation that no representative sample could be secured. For this reason the sample of the subsoil is a mixture of the several strata to a depth of 6 feet, the average texture being that of a fine sandy loam. The light friable nature of the soil permits of ease of cultivation.

The one body of Mocho fine sandy loam in the area is located just west of Pleasanton along both sides of the Arroyo del Valle near its junction with the Arroyo de la Laguna. Its total area is about three-fourths of a square mile. Except for the depressions and the ridges of sand that have been formed by the waters of the Arroyo del Valle when it overflowed its banks, the type is level, and as both soil and subsoil are porous, the drainage is really too thorough.

The Mocho fine sandy loam is composed of successive layers of sediment brought down by the Arroyo del Valle at flood stages and deposited over the overflowed area.

Every acre of the Mocho fine sandy loam is under cultivation, and the only remaining native vegetation is an occasional valley oak or sycamore. A small part of the type has been planted to hops for a number of years with good results. Most of it is at present being profitably used for sugar-beet growing. In addition to these crops, truck should do well on all the type.

Like all other light-textured soils, the best results can be secured only by exerting every precaution to conserve moisture. The yields and at the same time the water-holding capacity can be increased by

plowing under some leguminous crop such as Canada field peas or by heavy applications of stable manure. Should an irrigation system ever be developed, this would prove one of the best truck soils in the area. At the present time none of the type is on the market, but it is valued at $200 to $300 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Mocho fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23114	Soil	0.0	0.2	1.0	21.0	26.0	41.5	10.0
23115	Subsoil	.0	.5	2.5	23.7	28.5	35.4	9.4

MOCHO LOAM.

In general, the Mocho loam consists of 18 to 24 inches of dark-brown or drab silty loam or sandy clay loam, underlain by alternating layers of sand, fine sand, and silty fine sand of a grayish-brown color. At between 3 and 5 feet this gives place to a heavy black clay or a dark-drab, mottled yellow, and gray silty clay loam. This heavy subsoil retains moisture well, while the lighter surface soil renders cultivation easy.

Two bodies of this type are found near Danville, one along Sycamore Creek and the other along San Ramon Creek. It is a recent alluvial soil, composed of successive layers of sediment derived chiefly from the soils of the adobe hills. The surface is comparatively level.

Fruit, hay, and grain are grown, the yields comparing favorably with those secured on other soils of this section. Potatoes and other truck crops have also been successfully produced, and under a system of thorough preparation and frequent cultivation this should be one of the best truck soils in the area. Applications of stable manure or the plowing under of some leguminous crop, such as cowpeas or vetch, would be beneficial. Land of this type ranges in value all the way from $100 to $300 an acre.

The results of mechanical analyses of soil, subsoil, and lower subsoil are given in the following table:

Mechanical analyses of Mocho loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23116	Soil	2.6	4.0	6.4	20.0	17.7	34.9	14.4
23117	Subsoil	.8	3.5	6.0	25.6	19.9	31.4	12.9
23118	Lower subsoil	.4	2.0	4.3	23.5	25.8	30.0	14.3

SANTA RITA LOAM.

The soil of the Santa Rita loam consists of a dark-gray slate-colored or nearly black loam or silty loam sometimes faintly mottled with bluish gray and brown. It is underlain at a depth of about 3 feet by a gray to brown silt loam of about the same texture as the soil. The subsoil is also somewhat mottled, gray and yellowish brown being the prevailing colors. Shallow pockets of a sandy loam are occasionally encountered.

Four bodies of Santa Rita loam have been mapped in the vicinity of Pleasanton. Their combined area does not exceed 1½ square miles, and the largest body embraces approximately one-third of this area. As a whole the type is comparatively level, although it usually has a perceptible slope, which, with the fact that the soil never becomes very compact, insures good drainage. On the other hand, as in case of other types of this series, the Santa Rita loam has a high moisture-holding capacity. The series is better in this respect than any other in the survey.

The Santa Rita loam is an alluvial soil, formed under swampy conditions. The original deposits, which from certain characteristics would seem to have been for the most part material originating in the adobe hills of the Diablo series, have been modified by the addition of large amounts of surface material carried down by the Arroyo del Valle and Arroyo de la Laguna and their branches.

In former times the type supported a growth of tules and a few willows. At present it is all under cultivation. The principal crops are hops, sugar beets, and alfalfa. The hop yields are large and the quality unexcelled. During favorable seasons from 12 to 16 tons of sugar beets per acre have been secured, while the average number of cuttings of alfalfa is four or five, with a total yield of 8 to 10 tons of hay per acre. These yields are considerably larger than can be secured on most other soils in the area.

All crops grown on this soil will be benefited by thorough preparation of the land, frequent cultivation, and applications of stable manure. Good results should also follow from the plowing under of some leguminous crop, such as cowpeas or vetch. The type is valued at $200 to $300 an acre. At present practically none of it is on the market.

The following table gives the average results of mechanical analyses of typical samples of soil and subsoil:

Mechanical analyses of Santa Rita loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23041, 23146...	Soil.....	0.1	0.6	1.3	6.4	32.2	41.3	17.9
23042, 23147...	Subsoil.....	.2	2.3	4.1	12.9	30.0	29.9	20.3

SANTA RITA SILTY CLAY LOAM.

The soil of the Santa Rita silty clay loam to a depth of 2 to 3 feet consists of a light to heavy silty clay loam of a dark-gray or dark-slate color. It is usually underlain by a lighter textured silty clay loam or silt loam of drab, brown, or slaty-gray color, mottled with blue and yellow. In this stratum, which extends to a depth of 4 or 4½ feet, pockets or thin strata of sandy loam are occasionally encountered. Below this the subsoil becomes a little heavier in texture, but aside from the fact that it is more mottled there is very little change in color except in a few cases where a layer of black clay is encountered in the lowest depths.

The body of the Santa Rita silty clay loam, lying southwest of Pleasanton, differs from the rest of the type in that the soil is not quite so black and the texture somewhat lighter, while the subsoil is heavier and, if anything, darker colored and shows more pronounced mottling, with blue and yellow or brown. When the moisture conditions are right, certain portions of the type show quite marked adobe characteristics. When not too wet this soil is very easily cultivated.

Six areas of the Santa Rita silty clay loam were found in this survey. All of these are located in the western part of the Livermore Valley and southern part of the Amador Valley, in the vicinity of Pleasanton. These areas are rather irregular in outline, some being mere strips along bodies of the Santa Rita clay adobe, while others are quite wide. The total extent of the type is approximately 2 square miles.

The type has a rather flat surface, cut here and there by shallow depressions which represent old drainage channels. The heavy texture and level topography result in poor drainage conditions, and before crops can be grown it has been found necessary to construct ditches through the greater part of the type. The areas now are generally well drained.

Like the clay adobe of this series, a large part of the type has been deposited under swampy conditions, the material being derived largely from deposits of streams, which have their sources in the adobe hills. Only a very small proportion of the type contains alkali salts in sufficient quantities to prevent the growing of most crops. Very little of the native vegetation remains, although there are a few willows and tules along the ditches. The alkali areas support a growth of salt grass.

Nearly all the type is under cultivation, being dry farmed to grain and hay or planted to sugar beets. That alfalfa may be grown on well-drained portions of the type is shown by several small, flourishing fields of this crop. The yields do not vary greatly from those secured on the other soils of this series.

This is one of the last soils to show the effects of drought, as the water table is near the surface, and by deep plowing, thorough preparation, and frequent cultivation many crops that could not be grown on the lighter textured and drier soils can be grown successfully on this type with only the natural water supply. Under irrigation almost any farm or truck crop may be grown.

The physical properties of the soil can undoubtedly be improved by the incorporation of organic manures. Some small areas would be benefited by more thorough drainage, preferably the laying of tiles, which should be placed deep enough to lower the water table. Land composed of Santa Rita silty clay loam is valued at $150 to $300 an acre.

The following table gives the average results of mechanical analyses of typical samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Santa Rita silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23148, 23150...	Soil.....	0.5	1.4	1.4	4.0	5.7	60.3	26.4
23149, 23151...	Subsoil.....	.3	1.5	2.1	6.7	15.7	46.3	27.1
23152.....	Lower subsoil...	.0	1.0	2.1	8.1	11.0	58.3	19.1

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCo_3$): No. 23149, 4.95 per cent; No. 23150, 7.76 per cent; No. 23151, 3.67 per cent; No. 23152, 1.89 per cent.

SANTA RITA CLAY ADOBE.

The soil of the Santa Rita clay adobe consists of a dark gray or slate-colored sticky clay carrying a high percentage of silt and practically no sand. In the lower depths it is frequently mottled with bluish gray, brown, and yellow. Pockets of a fine sand and silty sand are occasionally encountered in all parts of the type. Some of the recently drained areas show more mottlings, and owing to the presence of large quantities of organic matter are darker colored, while layers of a peaty material are not uncommon in the lower depths. Occasionally the soil continues to a depth of 6 feet or more, with only slight changes in texture and little or no change in color. Usually, however, it is underlain at a depth of 3 to 5 feet by a rather compact layer of slaty black heavy clay, which continues to a great depth, resting upon a stratum of gravel from 25 to 50 feet below the surface.

That part of the Santa Rita clay adobe which occurs near Santa Rita and Dougherty is quite variable, differing considerably from the typical soil. In these localities the soil may be clay 12 to 18 inches deep, underlain by alternating layers of silty fine sand and

clay which rests upon a heavy black clay at 3 to 4 feet, or there may be from 3 to 5 feet of thin alternating strata of fine sandy loam and silty clays, resting upon the same heavy black clay. Although these areas are somewhat lighter in texture than the main part of the type, the differences seemed hardly sufficient to warrant a separate classification.

The type never puddles, but cracks and checks in such a manner as to produce a friable surface easily cultivated when once it has dried sufficiently. Although large clods are sometimes turned up in plowing, they soon break down under the action of the sun and wind.

Two bodies of Santa Rita clay adobe have been mapped in the area. The largest is located just northeast of Pleasanton and extends nearly to Santa Rita, embracing approximately 3 square miles. A smaller body occurs in the San Ramon Valley near Danville.

The type is generally very flat, with no perceptible slope. Except for the small "hog wallow" areas, there is scarcely any change in the uniformly level topography. This, together with the heavy nature of the soil, results in poor drainage conditions, and before crops can be grown over a large part of the type it is necessary to construct deep ditches to carry off surplus water. Even with this precaution water frequently stands on the surface for long periods during the wet season. As the water table is near the surface, attempts have been made to lower it by sinking wells to the gravelly stratum at a depth of 30 to 50 feet.

The Santa Rita clay adobe probably represents what was at one time a shallow lake, which gradually filled until it became a tule swamp. Streams laden with sediment from the adobe hills entered this quiet body and deposited their load, thus giving rise to the finest textured soil in the area. Since the lake has been drained fine material, in some cases several feet in thickness, has been deposited on the surface.

Alkali is found in a large part of the type, and in some cases the concentration becomes so great as to prohibit the growing of the majority of farm crops. Fortunately, in the majority of cases there are comparatively small amounts of these salts in the first foot, and hay and grain are grown successfully even on areas where the percentage for the first 6 feet of soil runs high.

Where this type has not been cleared and drained, it still supports a dense growth of tule, while willow abounds along the stream channels. The uncultivated areas with considerable alkali in the first foot are covered with salt grass and some alkali heath. The greater part of the type is under cultivation, those areas in which the amount of alkali is not too great being devoted to sugar beets. In growing this crop large quantities of stable manure are applied, which show beneficial effects in the resulting yields. On other portions of the

type hay and grain are grown. The ordinary yield of sugar beets ranges between 12 and 16 tons and of hay from 1 ton to 2 tons per acre.

Much of the Santa Rita clay adobe carries too high a percentage of alkali to allow the cultivation of other than hay or grain crops. The better areas are well suited to the production of alfalfa and many other crops, as the water-holding capacity is great enough to insure fair yields. A supply of water suitable for irrigation can be secured from wells 30 to 50 feet deep, and the time may come when it will pay to irrigate those portions of the type which are free from alkali. Great care must necessarily be exerted in irrigating alkali areas or the concentration will be so increased in the surface foot as to prohibit the growing of even hay and grain crops. Much of the type would be improved by more thorough drainage. The value of Santa Rita clay adobe ranges from $150 to $300 an acre.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Santa Rita clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
22496, 23158..	Soil.....	0.0	0.1	0.5	1.9	12.3	43.9	41.3
22497, 23159..	Subsoil.....	.0	.2	.3	.4	1.9	54.1	43.1

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 23159, 0.72 per cent.

LIVERMORE FINE SANDY LOAM.

The soil of the Livermore fine sandy loam, to a depth of about 2 feet, consists of a light to heavy fine-textured sandy loam which is brown when dry and brown, with a reddish tinge, when wet. This is underlain by a yellowish or yellowish-brown fine sandy loam generally finer in texture than the soil and grading at about the fifth or sixth foot into a yellowish-brown sand or loamy sand. On the narrow ridges the sand in the soil becomes coarser and some gravel is frequently present, while the lower subsoil is a gravelly sand or even a gravel. Because of its loose, friable nature the type is readily tilled at all times.

Only one area of Livermore fine sandy loam, comprising less than 1 square mile, is found in this area. This body, which lies about 2 miles northeast of Pleasanton, is very irregular in outline and forms a connected series of ridges which mark the course of old stream channels.

The porous nature of both soil and subsoil and the sloping or rolling topography insure good drainage, even during the wet season.

During the dry season, however, crops show the effects of an insufficient water supply.

The Livermore fine sandy loam is a colluvial and alluvial soil, the materials of which have been derived largely from the Pleasanton series. No alkali occurs in this type. The area is treeless and all under cultivation, being dry farmed to grain and hay. The yields are somewhat lighter than on the adjoining bodies of Livermore loam. From 20 to 25 sacks of barley is not an uncommon yield, and the average hay crop is from 1 to 2 tons per acre.

The cost of leveling this land for irrigation would be comparatively little, and providing an adequate water supply can be obtained the type should prove an excellent soil for small fruits, truck, alfalfa, and in fact almost any farm crop.

The present yields could be greatly increased by plowing under some leguminous crop or by the application of stable manure and by deeper preparation and more thorough cultivation. Land of this type is valued at $150 to $250 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Livermore fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Pec cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23092	Soil	0.9	2.3	5.4	28.5	23.4	29.7	9.9
23093	Subsoil	.4	1.9	4.7	30.6	23.0	31.1	8.4

LIVERMORE SILTY FINE SANDY LOAM.

The Livermore silty fine sandy loam consists of 36 inches of silty fine sandy loam, which is brown when dry but has a reddish tinge when wet. It is underlain by yellowish or brown fine sandy loam or silty fine sandy loam. In general, both soil and subsoil contain relatively large proportions of fine and very fine sand, although some small ridges of coarser soil and a few depressions of silty loam have been included in the type. A loose, friable structure and sandy texture make cultivation easy.

Two bodies of Livermore silty fine sandy loam, having a combined area of nearly 1 square mile, have been mapped. Both of these occur along the Arroyo del Valle in the vicinity of Pleasanton. The surface is generally level to slightly rolling, with many ridges and depressions marking the course of abandoned stream channels. The porous nature of both soil and subsoil always insures good drainage.

The Livermore silty fine sandy loam is composed of colluvial and alluvial deposits derived largely from soils of the Pleasanton series.

In former times it is probable that there was a scattering growth of oaks on this type, but at present it is all under cultivation and devoid of native vegetation.

A large part of the type is in orchard fruits. The trees are in a flourishing condition and often yield well, but in most cases the fruit is inferior in size—a result of insufficient moisture during the summer season. Some small truck farms are located on this type. Where properly tended such crops do well, especially in the late winter and spring. There are also several acres in alfalfa, which seems to flourish, giving fair crops.

Under irrigation almost any crop suited to the climatic conditions could be grown, but to secure the best results under present conditions the land needs thorough preparation and frequent cultivation, together with heavy applications of stable manure. The soil would also be benefited by plowing under green manuring crops, preferably field peas, cowpeas, or vetch.

Land of this type of soil is valued at $150 to $300 an acre, depending on location, improvements, and state of cultivation.

The following table gives the results of mechanical analyses of typical samples of soil and subsoil of this type:

Mechanical analyses of Livermore silty fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23094	Soil	0.0	0.2	0.5	14.6	32.8	41.9	9.9
23095	Subsoil	.1	.2	.5	16.9	31.8	41.3	9.1

LIVERMORE GRAVELLY SANDY LOAM.

The soil of the Livermore gravelly sandy loam consists of 2 to 3 feet of a very dark brown or reddish-brown loam, carrying variable quantities of gravel. Some small areas included with the type have barely enough gravel to justify classing them a gravelly loam, while in other cases the gravel constitutes fully 60 per cent of the soil. In most areas the content is high. The gravel consists chiefly of flattened or angular fragments of a great variety of rocks. The interstitial material contains perceptible quantities of medium and coarse sand, with enough clay particles to give the soil a sticky feel when wet.

In many cases the difference in color between the soil and subsoil is so slight that the line separating them is very indistinct. As a rule, however, the latter is a shade lighter in color. While there are larger amounts of a somewhat coarser gravel and some cobbles in the subsoil, the interstitial material is of about the same texture as that

found in the soil. The subsoil becomes coarser with depth, until at 6 feet or more a bed of coarse gravel and cobbles is encountered.

A distinct phase of this type occurs on the low terraces lying only a few feet above the stream channels. There the color of the soil is usually dark brown or nearly black, and the content of gravel frequently higher than in the reddish-brown areas lying on the higher terraces. In the dark phase the underlying coarse gravel is usually nearer the surface than under the remainder of the type.

There is a small area near the point where the Arroyo Seco emerges from the hills into the valley proper which is not typical, but on account of its limited extent has been included with the type. This area is only slightly heavier in texture, but it contains very much less gravel, and if it were of sufficient extent would be recognized as a separate type.

The type is closely associated with the soils of the Pleasanton series in the southern half of the area, where bodies occur ranging in size from a few acres to several square miles. The largest and most important body lies along Arroyo Mocho, and beginning several miles up that creek extends 2 miles beyond Livermore. Just west of that town it joins with another body from the Arroyo del Valle, along which creek there are also a number of small isolated areas. In the La Costa Valley there are two moderate sized bodies, besides a number of smaller areas along the intermittent stream channels coming from the hills in this section of the survey.

The type occurs on benches and more or less well-defined terraces along the creeks. Aside from the elevations and depressions, representing abandoned stream channels, and the abrupt slopes from one terrace to another, it is comparatively level. In many cases the terraces are very well defined, and there is an almost vertical drop of 20 to 30 feet from the earlier to the more recent. Owing to the extremely gravelly nature of the soil, the drainage is excessive, and only by the employment of most thorough and intelligent methods can the majority of crops be grown successfully.

For the most part the Livermore gravelly sandy loam is composed of colluvial and alluvial material, derived almost entirely from materials washed from the more or less gravelly soils of the Pleasanton series. The heterogeneous mixture of coarse and fine material seem to indicate that the type has been formed by swiftly flowing water. There are a few small areas along the minor streams and a number of small bodies which have been formed where these streams emerge from the hills and spread over the valley floor. Here the type is largely colluvial.

With the exception of an occasional valley oak the type is devoid of trees, the native vegetation being burr clover and alfilaria. A large proportion of the type is dry farmed to grain and hay, but

unless the season is especially favorable the yields are light, from one-half to 1 ton of hay being considered a fair average. It is on this type that a large proportion of the wine grapes are produced. The yield is not large, but the quality is unexcelled for the manufacture of wine. Some attempts have been made to grow tree fruits, but owing to a lack of an adequate water supply the industry has been practically abandoned. It is quite probable that alfalfa, fruit, and general farm crops would do well under irrigation.

More thorough cultivation, deeper preparation, and employment of every means for conserving soil moisture is advised. Great benefits would also be derived from the application of stable manure and from green manuring.

The Livermore gravelly sandy loam is valued at $50 to $300 an acre, depending on location, improvements, and state of cultivation.

The following table gives the average results of mechanical analyses of typical samples of soil, subsoil, and lower subsoil of this type.

Mechanical analyses of Livermore gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23086, 23089.....	Soil.....	10.1	10.5	6.7	12.0	11.7	36.8	12.2
23087, 23090.....	Subsoil.....	14.2	17.6	12.2	14.2	9.1	20.9	11.4
23088, 23091.....	Lower subsoil.....	32.2	19.5	6.9	7.9	4.8	17.3	11.5

LIVERMORE LOAM.

The soil of the Livermore loam consists of a dark-brown, or brown having a reddish tinge when wet, silty loam, with a relatively high content of fine and very fine sand. Generally there is some gravel scattered over the surface and distributed through the soil, the quantity often being considerable in those areas adjoining bodies of Livermore gravelly sandy loam.

The soil is underlain at a depth of 2½ to 3 feet by a brown, light-brown, or sometimes reddish-brown silty loam or silty fine sandy loam, which in the upper part is considerably lighter in texture than the soil, but which becomes heavier and siltier with depth until at the fifth or sixth foot a yellowish silt loam is frequently encountered. Very little or no gravel is found in the subsoil.

The Livermore loam occurs as strips and irregular shaped bodies of all sizes up to 1 square mile or more in extent. The greater proportion of the type is found in that part of the valley floor which lies south of the Arroyo las Positas and between the town of Livermore and the Santa Rita-Pleasanton road. There is also one small body near Sunol, two east of Livermore, and three southwest of

Pleasanton. The three last mentioned differ somewhat from the typical bodies of this soil, but their combined area was hardly great enough to justify establishing two new types.

The topography of the Livermore loam is for the most part comparatively level, although the surface is frequently interrupted by ridges and depressions of abandoned stream channels. Although the type is rather flat, the soil and subsoil are not compact enough to obstruct the downward movement of water, and the crops never suffer from poor drainage conditions. On the other hand, the texture is such that the soil can, by intelligent management, be made to retain sufficient moisture to carry crops through long dry periods. The Livermore loam is a mixture of colluvial and alluvial materials that have been washed from the soils of the Pleasanton series.

This is one of the easiest tilled and most important types of the Livermore series. At present it is all under cultivation and treeless, although in former years it supported a few valley oaks. It is devoted almost entirely to hay and grain production. The majority of farmers follow some system of rotation by which the land is in pasture every third or fourth year. Under such methods the ordinary yields in a favorable season are as follows: Hay, 2 to 3 tons; barley, 25 to 30 sacks; and wheat, 20 to 25 sacks.

Some grapes and a few fruit and almond orchards are found on this type. The former do fairly well. While the fruit and almond trees flourish and bear abundantly of fruit in some seasons, owing to an insufficient moisture supply the fruit is nearly always inferior in size and unable to compete with that grown in more favorable sections. If irrigation water can be supplied this will undoubtedly prove one of the best fruit and alfalfa soils in the area.

Deeper preparation of the soil and more frequent cultivation and application of stable manure are advised for all cultivated crops. The Livermore loam is valued at $150 to $300 an acre.

The following table gives the average results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Livermore loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23037, 23098.....	Soil.....	0.3	1.2	2.5	15.7	29.9	32.1	18.2
23038, 23099.....	Subsoil.....	.3	.8	1.8	11.4	17.9	49.3	18.4

LIVERMORE CLAY LOAM.

The soil of the Livermore clay loam, to a depth of 3 or 4 feet, consists of a very dark grayish-brown to dark-gray clay loam or silty

clay loam. Frequently small quantities of gravel are found on the surface and distributed through the soil. The soil becomes rather hard on drying and has a tendency to bake and check. The subsoil is a grayish or yellowish-brown clay loam which is similar in texture to the soil, but frequently becoming rather compact and heavier near the sixth foot.

Several bodies of Livermore clay loam have been indicated on the map, all of which are confined to that part of the valley lying between Livermore and Pleasanton. The largest body embraces nearly 1 square mile while the smallest body is only a few acres in extent.

The type is comparatively level, although occasionally interrupted by depressions representing old stream channels. As a rule the drainage is excellent and at the same time the texture of the soil enables it to retain a large supply of moisture.

The Livermore clay loam, like the rest of this series, is composed of colluvial and alluvial material formed from stream sediments derived from wash of the Pleasanton soils.

With the exception of an occasional valley oak, the type is devoid of trees. It is devoted almost entirely to grain and grass, the yields being large. Hay yields from 2 to 4 tons in favorable seasons, and the average crop of barley ranges from 20 to 30 bushels per acre, depending upon the preparation and condition of the land.

The supply of available moisture in the soil is hardly sufficient to produce fruit of a size and quality to compete with that grown in irrigated sections. Should an irrigation system be established, this would prove an excellent soil for fruit, alfalfa, and general farm crops. At present the yields could undoubtedly be increased by deeper plowing, more thorough preparation, by the application of stable manure, or by plowing under green manure crops. Very little of this land is on the market. It is valued at $150 to $300 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Livermore clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23096	Soil	0.4	1.5	1.6	9.9	21.8	41.1	23.7
23097	Subsoil	1.1	3.4	3.3	8.9	21.1	38.2	24.0

LIVERMORE CLAY.

The Livermore clay in its typical development consists of a dark chocolate-brown to dark-gray clay, with about 6 inches of a lighter textured soil on the surface. The soil is generally quite compact

and is inclined to bake and check as it dries. Some areas have small amounts of gravel scattered over the surface and distributed throughout the 6-foot profile. At about 2½ to 3½ feet the soil is underlain by a grayish-brown or light-brown clay loam, lighter in texture and usually more silty than the soil. This material may hold throughout the remainder of the profile or the subsoil may grade into a lighter colored and more compact clay loam between the fifth and sixth foot. Taken as a whole the type is subject to considerable variations, for while some bodies are a light-textured clay loam, other areas encountered are very heavy clay. As the type is sticky when wet and as it becomes compact on drying, it is more difficult to cultivate than the other soils of this series, unless handled when the moisture conditions are right.

The Livermore clay is a valley soil confined to the southern half of the area. Several bodies ranging in extent from one-eighth to 1 square mile have been recognized and mapped. The greater proportion of the type lies just east and southeast of Livermore. There is, however, one important body northwest of that town, and a much smaller body that has recently been planted to English walnuts, in the Alameda Creek bottom near Sunol. For agricultural use the last-mentioned body is probably the best part of the type.

The Livermore clay is comparatively flat, although the surface is interrupted by abandoned stream channels. The water drains off rather slowly from parts of this type, as the compact structure retards its downward movement. Some of the lower lying areas may be flooded for short periods during the rainy season. However, when the rains cease the soil dries off rapidly and in the majority of cases there is no necessity for artificial drainage.

The Livermore clay consists of both colluvial and alluvial deposits of streams whose sources are chiefly in soils of the Pleasanton series, and the deposited material is made up largely of wash from the soils of that series.

Aside from an occasional valley oak, the Livermore clay is treeless and at present all under cultivation. It is largely utilized in the production of hay and grain, the common practice being to pasture the land every second, third, or fourth year. The grains produce from 2 to 3 tons of hay per acre and barley 20 to 30 sacks of grain, the yields depending on the season and the thoroughness with which the fields have been prepared.

The rainfall is hardly sufficient to insure success in growing a wide range of farm crops, but under irrigation alfalfa and fruit would undoubtedly do well. Even without irrigation there is little doubt that the yields could be increased by applications of stable manure and lime or by plowing under some leguminous crop, such as cowpeas or vetch. The Livermore clay, where on the market, sells for $100 to $200 an acre.

The following table gives the average results of mechanical analyses of typical samples of soil, subsoil, and lower subsoil:

Mechanical analyses of Livermore clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23039, 23103, 23106.	Soil.....	0.3	0.8	1.1	6.5	16.3	44.5	30.4
23040, 23104, 23107.	Subsoil.....	.5	1.4	2.0	10.9	13.5	44.3	27.5
23105, 23108.....	Lower subsoil.	1.1	3.1	3.6	15.1	14.6	36.4	26.1

DUBLIN LOAM.

The Dublin loam includes a number of small bodies of soil which show more or less variation in color and texture, but which because of their common origin and similarity in agricultural value have been mapped as one type. Generally speaking the soil consists of a dark-brown to nearly black heavy loam carrying considerable quantities of sand and enough clay to make the soil decidedly sticky. Some areas, however, are quite silty, and others contain small quantities of gravel and rock fragments.

At 2 to 3 feet the soil changes to a dark grayish-brown heavy loam or silty loam which persists to a depth of 6 feet. Pockets and thin strata of sand or sandy loam are frequently encountered in the subsoil. At times parts of this type show quite marked adobe characteristics.

Several small bodies of Dublin loam have been mapped in the northwestern part of the survey. The two most important of these occur along Alamo and Sycamore Creeks, near their sources. The level topography, excellent drainage, and friable nature of the surface render tillage easy.

The type is composed largely of colluvial material, with a slight admixture of alluvium derived from the adobe hills, and usually supports a few oaks, with some willow and sycamore along the stream channels.

At present all of the Dublin loam is under cultivation, the greater part being dry farmed to hay or grain. The yields of hay range from 1 to 3 tons and of barley from 15 to 25 sacks per acre. A number of orchards of peaches and other fruit are found on the type, and where given the proper care fair yields are obtained, although the fruit is sometimes rather small. Under irrigation this type would undoubtedly prove an excellent fruit, truck, and alfalfa soil. Beneficial results will follow applications of stable manure, together with deeper plowing and more frequent cultivation.

The following table gives the average results of mechanical analyses of typical samples of soil and subsoil of this type:

Mechanical analyses of Dublin loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23076, 23078.....	Soil.....	0.6	2.4	3.9	18.4	31.7	25.3	17.5
23077, 23079.....	Subsoil.....	.6	3.4	5.0	19.0	26.9	25.7	19.2

DUBLIN CLAY LOAM.

The soil of the Dublin clay loam is a very dark brown to black, light-textured clay loam or heavy silt loam. More or less angular gravel is found scattered over the surface and distributed through the soil, and it is underlain at 1 to 2 feet by light-brown loam or light clay loam. This becomes lighter in color and texture with depth, usually grading into loam at 4½ to 5 feet below the surface.

With the exception of one body in the Sunol Valley, all of this type occurs along the eastern slope of the range of hills that forms the western boundary of the area. These bodies cover an area of one-eighth to 1 square mile each. The type is never flat, as there is a perceptible slope from the hills on one side toward the main valley. The slope is usually sufficient to carry away the surface waters in the wettest seasons. On the other hand, the physical characteristics peculiar to this soil enable it to absorb and retain large amounts of water.

The Dublin clay loam is composed of colluvial and alluvial material largely derived from the adjacent adobe hills. This has been spread over the valley floor as irregular and somewhat fan-shaped areas near the points where the intermittent streams emerge from these hills.

All of the type is under cultivation, and, aside from an occasional valley oak, is treeless. At present practically all of it is dry farmed to hay and grain. Hay in a favorable season yields from 2 to 3 tons, oats 30 sacks, and barley from 25 to 26 sacks per acre.

Some fruit trees are found, and these are usually in a healthy condition. Peaches, apricots, and prunes bear in abundance, but even by the use of every precaution to conserve the soil moisture the rainfall during the spring and summer months is seldom sufficient to produce a crop of a quality to compete with fruit grown in more favorable sections. However, if irrigation should ever become practicable on this type it will be suited to a wide range of farm crops.

As the Dublin clay loam is naturally a productive soil, better yields can be secured by giving more attention to the preparation and cultivation of the land. The type is valued at $150 to $300 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Dublin clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23080	Soil	1.3	2.4	1.7	11.6	10.7	47.7	24.4
23081	Subsoil	2.0	3.0	2.1	14.7	31.5	28.4	18.4
23082	Lower subsoil	.6	1.1	1.2	11.9	34.9	31.8	18.4

DUBLIN CLAY LOAM ADOBE.

The surface soil of the Dublin clay loam adobe consists of a dark-brown to black clay loam that carries small amounts of shale and angular rock fragments. During dry weather the land checks and cracks, but at other times the adobe characteristics are never very marked. The dry cultivated surface has a reddish-brown cast. The soil is underlain at 18 to 24 inches by a rather compact clay loam, or clay a little lighter in color than the soil. At about 48 to 60 inches this gives place to a yellowish-brown or yellow clay loam which continues to a depth of 6 feet. The texture and drainage conditions are such as to make the question of handling the soil a comparatively simple one.

Two bodies of this type embracing approximately 2 square miles have been mapped in the area. The largest of these lies just southeast of San Ramon, while the other is located east of Danville. The type is slightly rolling, and slopes gently from the hills on the one side toward the valley on the other. The slope and physical properties insure good drainage at all times.

The Dublin clay loam adobe is composed of colluvial and alluvial material that has been washed down from the adjoining slopes or carried from the higher hills by the streams and spread over the valley floor.

At present the type is all under cultivation, the native vegetation, except a few valley oaks, having been removed. It is dry farmed to grain and hay, and yields from 1 to 3 tons of hay and 25 to 30 sacks of barley per acre. The land is valued at $100 to $250 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Dublin clay loam adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23083	Soil	0.0	0.4	1.4	16.0	24.9	27.3	30.1
23084	Subsoil	.0	.7	1.2	14.7	23.3	28.0	32.0
23085	Lower subsoil	.0	.7	1.5	14.8	28.3	33.1	21.9

DUBLIN CLAY ADOBE.

The Dublin clay adobe, to an average depth of 12 to 15 inches, consists of a dark slate-colored to black sticky heavy clay, underlain by a very dark brown to black compact clay. At a depth of 3 to 4 feet, or even 5 feet in a few cases in the Amador Valley, the clay subsoil gives way to a yellowish or yellowish-gray compact clay, which extends to a depth of many feet.

The lower subsoil is, however, subject to considerable variation in texture. Sometimes it approaches a silty clay loam; in other cases it becomes quite sandy, the particles being rather coarse. Pockets of gravel are occasionally found.

This type changes so gradually into the Diablo clay adobe of the hills and the boundary is so indefinite that it frequently becomes necessary to separate the two types largely by a difference in topography.

In the soil, the cracks, which are characteristic of all adobe soils, are, generally speaking, larger and more abundant than in other adobe types in this area. While the type seldom puddles, it does not lend itself as readily to tillage as the hill adobe, being more compact and not as well drained. A few small bodies of a lighter textured clay are included in this type, but the difference in agricultural value and the extent of such areas hardly seemed to justify a separation.

The type occurs in all parts of the survey, but chiefly in the northern half, where it reaches its most typical development. The largest uniform body, covering several square miles, lies just north of Livermore. This body continues west along the southern slope of the adobe hills with but a single break and extends up the San Ramon Valley nearly to Danville. In addition there are many small flats of the type along the stream courses in the hills to the north, while in the eastern and southern parts of the survey small bodies have been included. These are, generally speaking, hardly typical.

The greater part of the type is comparatively level, although there is nearly always a perceptible slope from the hills toward the drainage channels. A few gently rolling areas are included, but they are exceptions.

While the slope of a large part of the type is sufficient to carry off the surplus surface water, there are large flat areas on which the water stands for days during the rainy season. As the heavy compact structure of both soil and subsoil prevents rapid percolation, such areas would undoubtedly be benefited by underground drainage. However, a distinct advantage which this soil has over many others in this area is its marked capacity for retaining moisture because of the compact nature of the subsoil. By using proper methods crops can be carried through comparatively long dry periods in fair condition.

In origin the Dublin clay adobe is largely colluvial, having been formed by wash from the black adobe hills together with stream deposits derived from the same source. A large part of the type carries alkali, and in the poorly drained areas the content becomes large, the highest percentage usually being found in the third and fourth feet. A small body of this soil just northeast of Livermore contains so much alkali that it can be used only for grazing until reclaimed.

The type is generally treeless except in the vicinity of streams, where a few willows and valley oaks are found. At present practically every acre is under cultivation. It has been dry farmed to grain and hay continuously for a number of years. It is now becoming a common practice to pasture the land every second or third year. In a favorable season from 1 to 3 tons of hay, from 20 to 25 sacks of barley, or 30 sacks of oats per acre are ordinary yields.

Because of the rather compact structure and the presence of alkali salts in the subsoil of a large proportion of the type it is doubtful if fruit growing will ever be successful. Under existing conditions it would seem that the soil is being utilized to the best advantage. The yields could be increased by deeper plowing and more thorough preparation to conserve moisture.

The greater part of the type is conveniently located as regards markets, and with the exception of a few small areas that carry a high percentage of alkali ranges in value from $100 to $300 an acre.

The following table gives the average results of mechanical analyses of typical samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Dublin clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23067, 23070	Soil	0.1	0.6	0.8	5.6	17.6	30.1	45.0
23068, 23071	Subsoil	.0	.6	.8	5.9	14.4	34.9	43.3
23069, 23072	Lower subsoil	.1	.9	1.2	7.1	21.4	33.2	36.1

ULMAR FINE SANDY LOAM.

The Ulmar fine sandy loam is a brown to light brown, sometimes having a reddish tinge, fine to medium light-textured sandy loam, varying in depth from 30 to 72 inches. It usually rests upon a dull-yellow heavier textured fine sandy loam, which is very frequently though not always underlain at 36 to 72 inches by a yellowish sandy hardpan. Occasionally there is practically no change in texture within the 6 feet or until hardpan is encountered. In some of the "hog wallow" areas the mounds are sandier than the typical soil, while in the depressions there is often a thin covering of clay over

the sandy loam. The surface is nearly always loose and friable and therefore easily cultivated.

All of the Ulmar fine sandy loam found in the area occurs in the northeastern corner of Livermore Valley, where a number of bodies ranging in size from a few acres to nearly a square mile are found. The greater part of the type is more or less marked by "hog wallows" and cut by old stream channels.

A few small areas of Ulmar fine sandy loam are composed chiefly of colluvial material, but the larger and more typical bodies owe their origin to the modification of Ulmar loam by stream action and by the succession of alluvial and colluvial material from the adjoining hills of Contra Costa sandy loam. Most of the type contains some alkali. The highest concentration found in the area occurs in this soil. The native vegetation consists of greasewood, alkali heath, and salt grass. Much of the type carries so much alkali that it is fit only for grazing. Other areas are dry farmed to grain and hay, the yields being as a rule very light. Land of this type ranges in value from $10 to $50 an acre. The better areas sometimes bring a little more than this.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Ulmar fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23171	Soil	0.4	6.0	8.8	20.7	21.0	32.9	10.0
23172	Subsoil	.4	4.2	8.0	20.4	23.1	24.8	19.0

ULMAR LOAM.

The Ulmar loam, to a depth of 15 to 24 inches, consists of a light-brown to dark-brown loam, sometimes reddish on the ridges, containing a relatively large proportion of fine sand. It is underlain by a sticky clay, which is yellow or brown, sometimes with a reddish tinge. At about 36 inches below the surface an impervious dull yellow sandy clay hardpan having a high content of lime is usually encountered. This hardpan is occasionally 3 feet or more in thickness, but as a rule it seldom exceeds 1 foot. It is underlain by a compact yellow clay loam. The hardpan is sometimes absent, and in such cases the subsoil rests at a depth of 36 to 60 inches on a very compact sandy clay loam or clay, which acts much like a hardpan. The southern half of the main body of the type is of this character. As these areas lack the true hardpan they are usually of somewhat higher agricultural value. That portion of the type which lies northeast of Ulmar has more of the reddish tinge than other areas of this soil. Some areas show a tendency to the "hog-wallow" topography, and in such cases there is apt to be considerable variation in texture, the hollows frequently being a clay loam, while the ridges are quite

light. The soil has a tendency to puddle, and although very spongy when wet it is apt to bake on drying, necessitating cultivation after each rain.

The Ulmar loam occurs in the extreme eastern portion of the valley floor, where there is a single body covering 3 or 4 square miles. It is comparatively level, except where interrupted by intermittent stream channels or marked by "hog-wallow" mounds or depressions a few yards in diameter.

The downward movement of water is arrested by the dense subsoil and hardpan, while the flat topography retards the flow of surface waters. As a result the soil is poorly drained, retaining much water on the surface in depressions and within the soil throughout the rainy season. The subsoil has a marked water-holding capacity, and this should, with frequent and thorough cultivation, greatly increase the supply of moisture available for the crops.

The exact origin of this soil is difficult to explain, but it probably consists largely of colluvial material with an admixture of alluvium. These materials have been washed largely from the brown soils of the Altamont series. The northern and eastern portions of the type contain more or less alkali, which in some cases is sufficient to injure crop growth.

The Ulmar loam has been, and a large proportion still is, used for grazing or devoted to the production of hay and grain. By summer fallowing every third year about 1 ton of hay per acre can be secured in a good season. The ordinary yield of grain is 8 to 10 bushels of wheat and 10 to 12 bushels of barley per acre.

Recently portions of this type have been subdivided and the tracts are being planted to strawberries, alfalfa, and truck. Where these have been irrigated by well water, pumped by windmills, fair results have been secured. Before undertaking fruit growing on a large scale thorough prospecting for hardpan and alkali salts is advised. If it is intended to irrigate, the character and quantity of water should be given careful consideration also.

Land of this type is selling in small tracts for $60 to $200 an acre, although the latter price is higher than the conditions and apparent agricultural value of the land would seem to warrant.

The following table gives the average results of mechanical analyses of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Ulmar loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23165, 23168...	Soil.....	0.8	3.0	4.4	13.2	20.8	37.1	20.3
23166, 23169...	Subsoil.....	.5	2.9	4.7	15.3	14.8	30.9	30.7
23167, 23170...	Lower subsoil...	.4	3.1	5.6	17.8	13.2	40.3	19.4

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 23167, 0.90 per cent.

DANVILLE CLAY LOAM ADOBE.

The soil of the Danville clay loam adobe is a dark-brown or black, light to heavy textured clay loam varying in depth from 24 to 36 inches and usually carrying more or less shale and angular rock fragments. It usually rests upon a light-brown or slightly reddish-brown loam or clay loam which is somewhat lighter in texture than the soil and frequently mottled with gray and yellow.

This soil is somewhat similar in origin and location to the Dublin clay loam adobe, but differs considerably in agricultural value. This is chiefly due to the fact that the subsoil of the Dublin clay loam adobe is heavier and very compact, while the subsoil of the Danville clay loam adobe is rather loose and spongy, thus enabling it to retain larger amounts of moisture. It is because of these differences that fruit trees are not successfully grown on the former, while some of the best results obtained in the area in fruit growing are secured on the latter type.

One body, embracing approximately one-half square mile, is found in the northwest corner of the area near Danville. It is composed of colluvial and alluvial material brought down from the adobe hills and spread over the valley floor in such a manner as to give a gradual slope from the hills toward the valley. The drainage conditions are excellent. Crops never suffer from lack of drainage nor from excessive drainage, as the subsoil retains moisture well. The excellent drainage conditions and friable nature of the soil render tillage easy.

The original tree growth consisted of a scattering growth of valley oak, but at present most of these have been removed and all the type is under cultivation, being dry farmed to grain and used for the production of deciduous fruits. Better success has attended fruit growing on this type than on any other soil in the area. This is attributable to three causes—first, the absence of a compact subsoil, which in many cases is detrimental to the growth of the trees; second, the marked moisture-retaining power of soil and subsoil; and third, the greater rainfall here than in other sections of the area. Like most other soils, the type is benefited by applications of stable manure and by plowing under some leguminous crop. Land of this type is valued at $150 to $300 an acre, depending on improvements and state of cultivation.

The results of mechanical analyses of the soil, subsoil, and lower subsoil are given in the following table:

Mechanical analyses of Danville clay loam adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23073	Soil	0.0	0.6	1.3	6.7	27.6	36.9	27.2
23074	Subsoil	.0	.4	.4	5.1	34.3	37.2	22.6
23075	Lower subsoil	.0	.1	.2	2.4	21.6	53.0	23.0

TASSAJERO CLAY LOAM.

The soil of Tassajero clay loam consists of 3 feet of dark-brown light-textured clay loam, which becomes a shade lighter in color at about 2 feet. Usually it is slightly mottled with gray and other shades of brown. These mottlings show only when the soil is wet. The dry cultivated surface is a reddish brown and under certain moisture conditions it appears somewhat like adobe, but these characteristics are seldom well enough defined to class the type as an adobe. Below 3 feet there is a lighter colored clay loam or sandy clay loam, which gives way to a dark-brown or nearly black heavy clay loam at about 4½ or 5 feet. Both the subsoil and lower subsoil are faintly mottled with shades of gray and brown. Where there are deep cuts along stream channels a layer of black clay or clay loam is frequently exposed several feet below the surface. The texture, drainage, and topography of the type are such that cultivation is easy.

Only two bodies, about 1 square mile in all, of Tassajero clay loam have been mapped in the area. Both of these occur in the northern part of the survey, the most important body being along Tassajero Creek and a smaller area about 3 miles farther east. Although the type is comparatively level, the slope is usually sufficient to carry off the surface waters, and the physical properties of the soil and subsoil insure fairly good natural drainage.

The Tassajero clay loam is an alluvial and colluvial soil and owes its origin to deposits derived largely from the red or reddish-brown adobe of the Black Hills region, although there is some admixture from the black adobe hills.

All the type is under cultivation, and devoted chiefly to the production of hay and grain, although some orchards of peaches, prunes, and apricots are seen. The trees in these orchards are large and apparently in a flourishing condition. An abundant crop is frequently secured, yet as in all other parts of the area the fruit is apt to be of an inferior size. The land is valued at $100 to $200 an acre or even more.

The following table gives the results of mechanical analyses of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Tassajero clay loam.

Number.	Description.	Fine gravel	Coarse sand.	Medium sand.	Fine sand.	Very fine sand	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23162	Soil	0.0	0.2	0.9	10.4	28.8	33.3	26.4
23163	Subsoil	.0	.8	1.3	17.9	21.0	35.9	23.1
23164	Lower subsoil	.2	.8	1.5	17.9	19.4	40.4	19.8

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 23163, 3.46 per cent; No. 23164, 1.84 per cent.

SUNOL LOAM.

The Sunol loam consists of 24 to 36 inches of a brown or reddish-brown heavy loam or light clay loam, carrying small amounts of angular rock fragments. It is underlain by a lighter brown loam or clay loam which in the upper part has about the same texture as the soil, but which becomes heavier with increasing depth.

Only three small bodies of this type have been mapped, all of which occur in the vicinity of Sunol. The total area is less than 1 square mile. The topography is comparatively level, although there is always a more or less perceptible slope from the hills toward the streams.

The Sunol loam is chiefly colluvium, although modified by some admixture of alluvial material. It owes its origin largely to stream sediments washed from the Pleasanton soils. The slope and texture are such as to insure good drainage conditions and ease of cultivation.

Formerly there were quite a number of valley oaks in this type, but at present many of these have been removed and the land is dry-farmed to hay and grain. The yields of the former range from 1 ton to 2½ tons. Under more favorable moisture conditions the type should prove well adapted to alfalfa and certain fruits. The present yields could be improved by more thorough preparation of the land and by plowing under legumes. Applications of lime would also prove beneficial.

Practically none of the land is on the market. Owing to location near the railroad the valuation is placed very high.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Sunol loam:

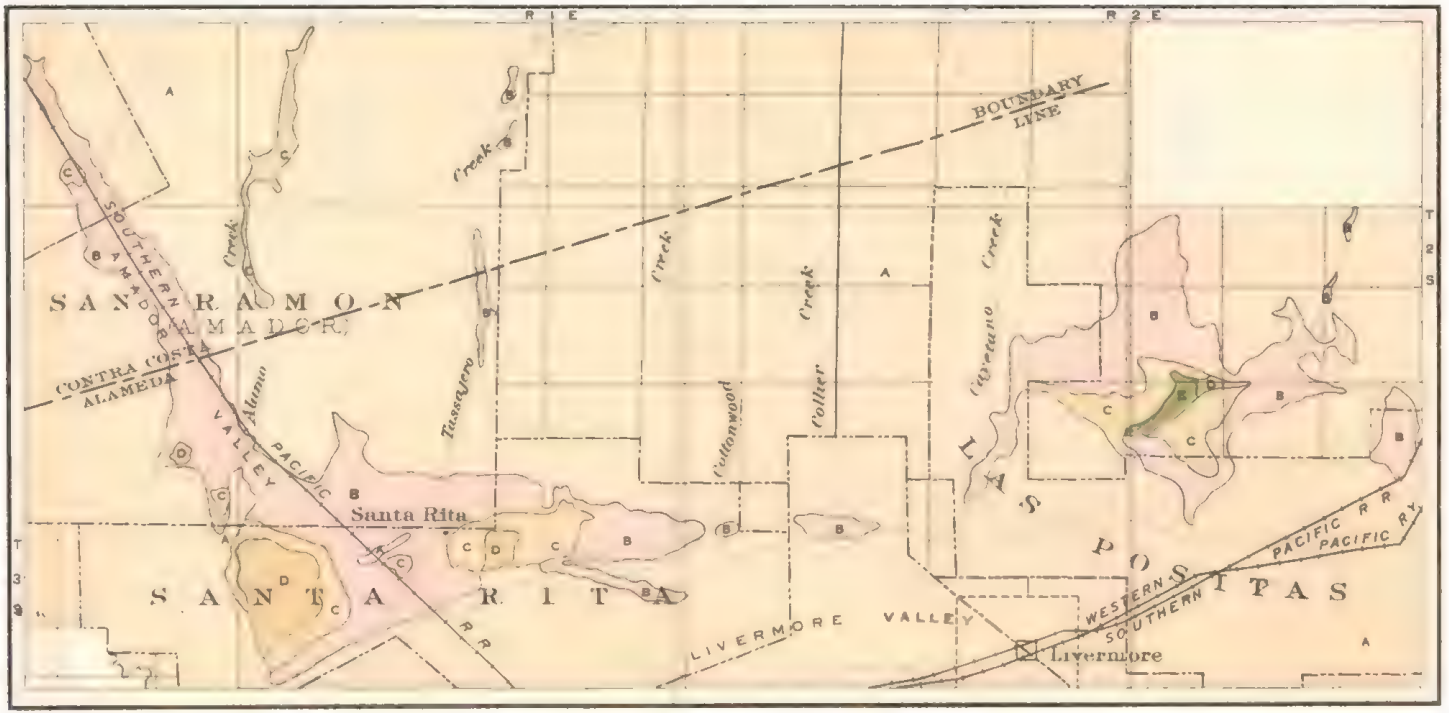
Mechanical analyses of Sunol loam.

Number	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
23160	Soil	0.2	0.9	1.7	10.9	15.4	48.3	22.4
23161	Subsoil	.5	1.1	1.9	10.8	30.9	34.1	20.8

ALKALI.

Areas in which alkali is present in sufficient quantities to harm crops are confined to the northern half of the Livermore area. Two large bodies, each several square miles in extent, have been mapped. The largest and most important of these lies in the Amador Valley, just south of San Ramon, and extends in a general southeasterly direction to a point 1½ miles north of Pleasanton. From this point it turns east along the Livermore-Santa Rita Road to within 3 miles

PLATE A.



ALKALI MAP, LIVERMORE SHEET.

A	B	C	D	E
Less than 200 parts per 100,000.	From 200 to 400 parts per 100,000.	From 400 to 600 parts per 100,000	From 600 to 1000 parts per 100,000	Over 1000 parts per 100,000.

Report of the Bureau of Soils, U. S. Dept. Agr. 1910.

of Livermore. The second important body, embracing 4 or 5 square miles, is situated about 4½ miles northeast of Livermore. There are also a number of smaller areas in this same section, besides several narrow alkali flats along many of the intermittent streams in the adobe hills.

The common salts, sodium chloride and sodium sulphate, occur here, but the more harmful sodium carbonate, or black alkali, was not detected to any extent. The greater part of these soluble salts is probably derived from the sandstones, limestones, and conglomerates that occur in the adobe hills to the north. The waters coming from these hills and bearing the salts in solution have overflowed the flats below and saturated the soils. Later, when the rains cease, the water evaporates and leaves the salts in the soil. That these salts sometimes extend to a considerable depth is shown by the fact that they are found in the well waters in those sections where alkali occurs.

The alkali conditions in the area are such as to cause considerable difficulty in establishing accurate boundaries. Some areas supporting a dense growth of alkali heath and salt grass, which usually indicate a high alkali content, contain a relatively small amount, the concentrations being in the surface foot. In other areas, and only a few rods distant, good crops were growing on soils that contained more than 500 parts per 100,000 in the 6 feet of soil. In such cases the maximum concentration was found in the lower 3 feet, the surface foot in which the shallow-rooted plants feed being comparatively free from alkali.

While the distribution of alkali salts through the 6 feet of soil for the different concentrations is subject to considerable variation, more or less uniformity was noted. For instance, in areas which have more than 200 and less than 400 parts per 100,000 the greatest concentration is more commonly found in the second, third, and fourth feet, although it may occur at any depth from the first to the sixth foot. Generally speaking, however, the first and sixth feet show the least. In those areas which have 400 to 600 parts per 100,000 of alkali the greatest concentration occurs more frequently in the first 3 or 4 feet, although, as in the preceding class, it may, and occasionally does, occur at all depths within the 6 feet of soil. Again, those bodies which show 600 to 1,000 parts per 100,000 in nearly every case have the greatest concentration in the last 3 feet, while in those few cases where there are 1,000 parts per 100,000 or more the alkali is generally quite uniformly distributed throughout the 6 feet.

The extent and position of the alkali areas will be seen in the alkali map (Pl. A) accompanying this report. The classification is based upon the average salt content to a depth of 6 feet as determined by field analysis, and areas of the different grades are distinguished in the map by color. Where the average alkali content is less than 200 parts per 100,000 no injury to crops need be feared under present con-

ditions, and many crops may be grown successfully on soils containing 200 to 400 parts per 100,000 of alkali. However, if this amount were contained in the surface foot of soil, grain crops would suffer somewhat, although as previously stated fair results are secured on soils where the average concentrations for the 6 feet runs as high as 600 parts per 100,000. This is due to the uneven distribution of salts, for the field examinations show very small amounts in the surface foot where such plants feed.

Although there are some small areas which can be used only for grazing, as a rule the alkali is so distributed that when dry farmed to grain fairly good results are secured. Any attempt to irrigate these soils is almost certain to increase the concentration in the surface foot to such an extent as to prohibit crop growth. To avoid this danger great care must be exerted to prevent by thorough underdrainage accumulation of water in the soil.

The efficiency of flooding, with the establishment of underground tile drainage, in the reclamation of alkali lands has been demonstrated in a number of cases, but the dense, impervious nature of the subsoil and the lack of an adequate water supply makes the reclamation of alkali soils in this area a difficult problem. While in most cases the establishment of a system of underground drainage is a comparatively simple problem, as there is no difficulty in finding an outlet for surplus waters, the only adequate and available water supply for flooding purposes here is from wells, and the land is hardly valuable enough at the present time to justify the expense of securing irrigation water by this method. However, the cost of pumping for land in the vicinity of Santa Rita would be comparatively little, as with wells sunk to a depth of 30 to 50 feet the water rises to within a few feet of the surface, and they may at certain seasons flow.

As the land in this section will grow almost any crop when freed from alkali, the time may come when it will pay to reclaim it.

SUMMARY.

The Livermore area includes parts of Alameda and Contra Costa Counties. It lies near the southeast corner of the former and northeast corner of the latter and has a total area of 155,520 acres. The topography varies from level areas in the valley to low hills which gradually rise to an elevation of 2,000 feet in remote parts of the area.

With the exception of a small section northwest of Pleasanton the drainage is generally well established.

The climate is one of the best and most healthful in the State. The mean annual temperature is 60° and while there are some very hot days in the summer, they are nearly always followed by cool nights. The average annual rainfall of 15.3 inches comes mostly in the months of December, January, February, and March. The sum-

mers are quite dry, rain in July and August being very uncommon. Fogs are comparatively rare, the number of foggy days seldom exceeding 10 or 12 a year.

The area is only 40 miles distant from the Oakland and San Francisco markets. Three lines of railroads traverse it. Shipping and marketing facilities are excellent. The main public roads are graveled and are always in excellent condition for hauling.

The principal crops grown are hay, grain, sugar beets, and grapes. By far the greater proportion of the area is dry farmed to grain and hay. Under continuous cropping the yields have decreased. They are now being increased and maintained by pasturing the land every second or third year.

In the early eighties about 4,000 acres were planted to grapes. Since then very few new vineyards have been set out. About 2,500 acres are still in a good bearing condition.

The greater part of the valley soils are adapted to irrigation and if an adequate water supply can be secured a wide range of crops can be successfully grown. The price of land ranges from $10 to $300 an acre, depending on locality, improvements, and character of the soil.

Five local types and eight series have been mapped in the area. Of these soils the Diablo clay adobe is most extensive. It is found in the hills in all parts of the area, but more particularly on the northern border. The type covers practically one-third the total area surveyed. This soil is largely residual and is characterized by black or dark-gray soil underlain by a lighter subsoil at about 3 feet. Practically all the type is dry farmed to grain and hay.

The Contra Costa sandy loam is an unimportant type in the area. It is a residual soil and is used for grazing or dry farmed to hay and grain.

The Altamont series includes two types, the clay loam and clay adobe. These are residual in origin, having been derived largely from the decomposition of calcareous sandstones. They are either utilized for the production of grain and hay or for grazing purposes.

The Vallecitos series embrace soil types that have been derived from the decomposition of metamorphic rocks. Most of the areas are so steep and hilly that they are used for grazing. The less rugged areas are dry farmed to hay and grain.

The Pleasanton series is probably sedimentary. It occupies the hills in the southern part of the area. The soils vary from gravelly sandy loams to clays. The most important type is the Pleasanton loam, on which a part of the wine grapes are grown. Other soils are either dry farmed to grain or else used for grazing. A large part of the series is so steep and broken that it is fit only for pasturage.

The Mocho series includes the most recent soils in the area, many of which are still in the process of formation. Most of them are

loose and porous and except in those cases where they are underlain by clays at comparatively shallow depths are inclined to be excessively drained. The Mocho loam, fine sandy loam, and sandy loam are the best truck soils in the area. Some alkali is found in parts of the Mocho sandy loam.

The Santa Rita series embraces soils near Pleasanton which are composed largely of wash from the adobe hills deposited under swampy conditions. Many of these soils carry alkali. The water table is near the surface and as the soils are very retentive of moisture certain crops that would fail on many other soils in the area can here be successfully grown. Sugar beets, alfalfa, hops, and truck do well on all these types.

The Livermore soils are confined chiefly to the Livermore Valley and have been derived largely from material washed from the Pleasanton series. Most of these soils are dry farmed to hay and grain, although part of the wine grapes are produced on the gravelly sandy loam type. While the yields are not large the quality is excellent. Under irrigation, alfalfa, fruits, and berry crops should do well on the soils in this series. Truck growing would prove profitable on the sandy loam and fine sandy loam.

The Dublin series consists of colluvial and alluvial soils composed largely of materials derived from the adobe hills. They occur chiefly in the northwestern part of the survey, and are excellent hay and grain soils. Under irrigation they would be adapted to a wide range of crops.

In the Ulmar series there are two types, the loam and fine sandy loam. These are colluvial and alluvial in origin and confined almost entirely to the eastern portion of the valley. These soils are quite frequently though not always underlain by hardpan at a depth of 3 to 4 feet, and where the hardpan is lacking it is replaced by a compact sandy clay. Most of their area is dry farmed to hay and grain, the yields being very light. A few attempts have been made to grow orchard fruits, but owing to the presence of hardpan or alkali the industry has not been successful up to the present time.

Only one small area of Danville clay loam adobe has been mapped in the area, but on this fruit growing has been more successful than on any other soil in the area. Favorable moisture conditions and a loose subsoil have been important factors in the satisfactory returns from fruit growing.

Other minor types are Sunol loam and Tassajero clay loam.

The common alkali salts are found in the area, but badly affected areas are confined almost entirely to the valleys in the northern half of the survey. High concentrations are sometimes found, but it is only occasionally that the concentration in the surface foot is great enough to prohibit hay and grain production.

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U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF

SOIL MAP

CALIFORNIA
LIVERMORE SHEET

SOIL PROFILE
(3 feet deep)
Sargy

- Livermore gravelly sandy loam: Grsl / Grsl
- Pleasanton clay adobe: C / C / Grcl
- Mocho sandy loam: C / Sl
- Livermore fine sandy loam: Fsl / Fsl
- Santa Rita loam: L / L
- Mocho fine sandy loam: Fsl / Fsl
- Livermore silty fine sandy loam: Si Fsl / Si Fsl
- Santa Rita silty clay loam: Sicl / Cl / Sil.
- Mocho loam: L / Cl / Fsl
- Livermore loam: L / L
- Santa Rita clay adobe: C / C
- Diablo clay adobe: C / Br / Cl
- Livermore clay loam: Cl / Cl
- Vallecitos stony clay loam: Cl / C / Br
- Altamont clay adobe: C / Br / C
- Livermore clay: C / C
- Vallecitos loam: Fsl / Br / Fsl
- Altamont clay loam: Cl / Br / Cl
- Pleasanton gravelly sandy loam: Grcl / Grcl / Grl
- Vallecitos clay adobe: C / C / Br / L
- Ulmar fine sandy loam: Fsl / Hp / Fsl
- Pleasanton gravelly clay loam: Grcl / Cl / Grcl
- Dublin loam: Fsl / Fsl
- Ulmar loam: L / Cl / C / Hp
- Pleasanton sandy loam: Sl / C / Grsl
- Dublin clay loam: Cl / L
- Contra Costa sandy loam: Sl / Br / C / Sl
- Pleasanton loam: L / C / Grsl
- Dublin clay loam adobe: Cl / C / Cl
- Sunol loam: L / L
- Dublin clay adobe: C / C / C
- Tassajero clay loam: Cl / Cl / Cl
- Yellow clay subsoil phase: L / C / Grsl
- Mocho gravelly fine sandy loam: Gr Fsl / Gr Csl
- Danville clay loam adobe: Cl / Cl
- Loam subsoil phase: L / Grsl

LEGEND

Grsl	Gravelly sandy loam	Sl	Sandy loam
Fsl	Fine sandy loam	Sicl	Silty clay loam
Si Fsl	Silty fine sandy loam	Sil	Silt loam
L	Loam	Br	Bedrock
Cl	Clay loam	Gr Fsl	Gravelly fine sandy loam
C	Clay	Gr Csl	Gravelly coarse sandy loam
Grcl	Gravelly clay loam	Hp	Hardpan
Grl	Gravelly loam		

LEGEND

- Livermore gravelly sandy loam: Lg
- Pleasanton clay adobe: Pa
- Mocho sandy loam: Ms
- Livermore fine sandy loam: Ls
- Santa Rita loam: Sl
- Mocho fine sandy loam: Mf
- Livermore silty fine sandy loam: Lf
- Santa Rita silty clay loam: Sc
- Mocho loam: Ml
- Livermore loam: Ll
- Santa Rita clay adobe: SR
- Diablo clay adobe: Dca
- Livermore clay loam: Lcl
- Vallecitos stony clay loam: Vs
- Altamont clay adobe: Ac
- Livermore clay: Lc
- Vallecitos loam: Vl
- Altamont clay loam: Al
- Pleasanton gravelly sandy loam: Pg
- Vallecitos clay adobe: Vc
- Ulmar fine sandy loam: Us
- Pleasanton gravelly clay loam: Pc
- Dublin loam: Dl
- Ulmar loam: Ul
- Pleasanton sandy loam: Ps
- Dublin clay loam: Dc
- Contra Costa sandy loam: Cs
- Pleasanton loam: Pl
- Yellow clay subsoil phase: Pl
- Loam subsoil phase: Pl
- Dublin clay loam adobe: Db
- Dublin clay adobe: Da
- Mocho gravelly fine sandy loam: Mg
- Sunol loam: S
- Tassajero clay loam: Tc
- Danville clay loam adobe: Dan
- Gravelly areas

Soils Surveyed by
H.L. Westover and Cornelius VanDuyne
1910

Base map from U.S. Geological Survey Sheets

Scale 62500
1 0 1 2 3 4 Miles
Contour interval 50 feet.
Datum is mean sea level.

The Eckert Litho Co Wash. D. C.

Field Operations
Bureau of Soils
1910